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Science Education

INTELLIGENCE, POWER AND PERSONALITY

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For many years my associates and I have been engaged in research on the nature of living processes. The basic unit of all living forms is the cell. What is the nature of a cell?

Whether independent or part of a complex form, every cell has two parts, a central nucleus and a surrounding cytoplasm. The nucleus and the cytoplasm are separated from each other and from their environment by exceedingly delicate lipoid films. Within these main divisions are minute subdivisions in the form of spherules and granules, also covered with delicate membranes.

The nucleus and the cytoplasm of a cell have opposite qualities, as indicated by the contrasting stains they absorb. The nucleus is relatively acid, and the cytoplasm is relatively alkaline. This chemical difference corresponds with an electrical difference. In other words, between the nucleus and the cytoplasm there is an electric strain, or potential difference, which makes it possible for an electric current to flow between them. The source of this electric strain is oxidation in the nucleus, which takes place on a higher scale than oxidation in the cytoplasm. This oxidation produces a surplus of positively charged hydrogen ions in the nucleus. As the electric charge increases in the nucleus, the current breaks through; the potential in the nucleus is thereby lowered, but it is immediately raised by continued oxidation.

The separating membranes, because of their extreme thinness and low electric conductivity, are ideally adapted for the storage of electric charge. For the thinner a film, the greater its capacity for storing electric charge. It has been estimated that the total surface area of the films surrounding the trillions of cells in the human body is about 9 acres, while the thickness of the film as measured in our laboratory is 1/2,500,000 cm., the thickness of a single molecule of oil.

Thus fundamentally the living cell exhibits the physical characteristics of an electric battery. The nucleus is the positive pole and the cytoplasm the negative pole. The semipermeable lipoid membranes of the cell act as condensers with their adaptation to storage and discharge of electric energy. During life a difference in electric potential, or electric strain, exists between nucleus and cytoplasm. When this potential falls to zero, death occurs. The nucleus and the cytoplasm respond equally to excitation and depression. Neither can exist independently of the other, and they undergo simultaneous dissolution in death.

We believe that the bipolar pattern of the living cell is found in all living organisms, from the simplest to the most complex. We believe that not only the individual unit of tissue, the cell, but the organism as a whole has a positive and a negative pole, with electric strain between these poles. As long as this difference in potential exists, life goes on. When the electric potential falls to zero, the state of equilibrium, the organism is dead.

What is the evidence which supports the bipolar theory of living processes?

The ameba, a minute animal resembling a speck of jelly, is composed of a single

cell. It is one of the simplest of living forms. The bipolar pattern is unmistakable. The nucleus takes a stain which indicates its acid reaction and its relatively positive electric charge. The rest of the ameba takes a stain which shows that the cytoplasm is alkaline and relatively negative.

Higher in the scale of animal life but still composed of a single cell is the diplodinium. Compared with the ameba it has a complex structure, representing a transition between the single-celled and the many-celled forms. The diplodinium has begun to take on the division of labor that is seen in the higher animals. The nucleus is the center of activity. It is closely connected with the cilia, which propel the animal like oars. The nucleus acts as a brain. The lines of communication between the nucleus and the cilia resemble nerves. The cilia may be considered as rudimentary limbs. Again the bipolar pattern is clear. The elementary brain and nervous system are positive as compared with the rest of the diplodinium.

This is the pattern of the simple cell and of the higher animals as well. The nucleus, behaving like a brain, produces positively charged ions and therefore constitutes the driving force of the organism. The cytoplasm depends upon the nucleus for delivery of force to it. The nucleus, or the brain, is the keyboard which governs this or that part of the organism, stimulating various types of activity. The nucleus and the connecting nervous system through oxidation generate positive ions. They perform no other work, form no secretion. The brain and the nerves are the master tissues of the body, directing the muscles and the various organs to perform their work.

We found additional evidence supporting the bipolar theory in laboratory production of an artificial cell resembling a single-celled organism.

We assumed that if living cells are minute electric batteries, it must be possible to separate animal tissues into their elements and rebuild them into structures having electric control and acting somewhat like living cells. This we did. Brain tissues were dried and ground up, and the three elementary constituents, lipoids, proteins and metals were separated from each other. The lipoid fraction was extracted with ether, the proteins were extracted with salt solution, and the nonsoluble metals were obtained by incineration. When these separated elements were again combined in a solution they formed autosynthetic cells which behaved in many ways like living cells. They took up oxygen and gave off carbon dioxide as if they were breathing. These autosynthetic cells exhibited a basal metabolism which was increased by the secretion of the thyroid gland, just as man and animals show an increased metabolism from the secretion of the thyroid gland. The metabolism was diminished by the administration of narcotics and anesthetics, as in the case of the higher animals. The cells were kept in culture for eight months, and underwent cell division comparable to that of cells everywhere. The nucleus-like center was electrically positive in relation to the remaining part. When the voltage was reduced to zero, the entire structure broke down. These autosynthetic cells seemed to represent the universal bipolar pattern of life.

We have mentioned oxidation in the brain as the source of the positive ions giving rise to the electric current which directs the work done by the rest of the body. What then could be the source of the vast amount of negative charge which actually performs this work? Electric measurements on living animals show that relative to the brain and nervous system, all other tissues, including organs and muscles, bear a negative charge. This negative charge is highest in the liver and in the left ventricle of the heart, both of

which contain large amounts of blood. Can this be explained by analysis of the blood itself?

A reply to this question is found by considering the unique qualities of the red blood cell. The red blood cell is surrounded by a film which according to actual laboratory measurement has a thickness of only 1/2,500,000 cm. Moreover, the red blood cell is a biconcave disk, a form which presents a large surface area. Here then is a mechanism ideally adapted for collecting and storing electric charge. But the red blood cell has no nucleus, and therefore cannot generate electricity within itself. If the blood is negatively charged, what is the source of the negative charge?

The explanation is found in a simple physical law. Static electricity is produced by friction. Stroke a cat and the fur sparks. Scuff your feet on the carpet and then feel the electric snap at your finger tips. The drops of water in a waterfall and the wind-swept particles of water in a cloud are negatively charged by the friction of the air. Any particle moving in air or in water picks up static charged according to a definite formula: The greater the friction and the higher the speed, the greater the accumulation of charge.

The blood passing through the left ventricle of the heart undergoes the force of the heart beat. The disk-shaped red blood cells are perfectly formed for tumbling and friction as well as for taking on and storing electricity. As these trillions of cells pass through the left ventricle, they take on negative charge which is held by the infinitely thin films on their surfaces. When the red blood cells reach the capillaries they are forced to slow down, and the static electricity is distributed to every microscopical unit of living matter in the body.

In testing this theory we have performed hundreds of experiments on laboratory animals. These tests show that as long as there is oxidation in the brain and circulation of blood, the brain is positively charged with respect to the rest of the body, which is negatively charged. In other words, there is a difference in potential, a potential gradient, between the positive and negatives poles of the body, the brain and the blood. We found by measurements with a specially constructed voltmeter that this potential gradient exists between the two poles of the body as long as there is life in the animal. When the potential gradient falls to zero, the animal is dead.

Typical charts of our experiments illustrate this fact. Interference with the blood flow through the heart, such as that caused by slow bleeding, produces a slow decline in the potential gradient between the brain and the heart. Intermittent clamping of the aorta produces a rise and fall of the gradient corresponding with the interruption of blood flow (Fig. 1).

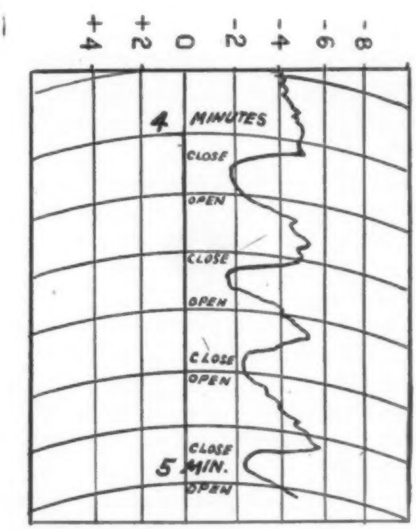

Figure 1.—Potential gradient between the brain and the heart of a rabbit; the curve falls and rises as the aorta is clamped and released.

A sudden shock to the nervous system caused by a shot through a major nerve

plexus in the shoulder results in immediate death which suggests putting out a light by turning a switch. The drop in potential gradient is spectacular.

Further evidence of the bipolar theory is furnished by photographs of tissue cells, particularly those of the brain and the liver. As stated, the potential difference is highest between these two organs. The positive or negative nature of the electric charge, as we have mentioned, is shown by the types of stain the cell absorbs. It is known that the products of the thyroid and adrenal glands, thyroxin and adrenalin, greatly increase the oxidation in the brain, which in turn stimulates the heart beat, thus increasing the activity of the entire body. According to our hypothesis, thyroxin and adrenalin would therefore increase the electric activity of the whole body, and this would be particularly observed in the cells of the brain and the liver. This is clearly shown to be true by the increased stainability of brain cells and liver cells. Thyroxin, however, creates this effect slowly, over a period of hours or days; adrenalin acts in a flash. If given together, they act with almost explosive force.

Not only are brain and liver cells electrically stepped up by agents which increase the activity of the whole body, but they are also electrically exhausted by agents which exhaust the body. Pain, infection, drugs, loss of blood and lack of sleep are such exhausting agents. This is seen in many photographs of brain and liver cells of animals and human beings in whom death has resulted from one or more of these causes.

If our ideas are sound, if electric energy produced by the bipolar mechanism is actually the basis of life, then intelligence, power and personality should be directly related to the energy-releasing organs. The character and activities of an animal should correspond closely with the relative and absolute size of the brain, representing the positive pole; of the heart and blood volume, representing the negative pole; and of the thyroid and adrenal glands, which step up oxidation in the brain and thereby increase the potential difference of the body, i.e. its working capacity, for long and short periods respectively. In addition, the nature of an animal should be reflected in the celiac ganglion, a nerve center like an abdominal brain which augments the action of the heart and vascular tree and thus electrically charges up the entire organism.

Throughout our study of animals we have found that these relationships do exist. In the museum illustrating our research is presented evidence that the relative and absolute size of the energy-releasing organs determines intelligence, power and personality.

In the past biologists have generally failed to correlate the energy-releasing system as a whole with the nature and activities of the animal, although different degrees of organization have long been observed in the animal world. Our researches took us over 100,000 miles, from the arctic to the tropics. In its course we collected 3,734 animals, representing 284 species. In all of these we found parallels between the energy pattern as shown by the life habits, and the energy-controlling organs: the brain, thyroid and adrenal glands, celiac ganglion, heart and blood volume.

An alligator and a lion of about the same weight illustrate the differences between the warm-blooded animal and the cold-blooded animal living on land. The alligator uses little energy. His movements are sluggish. He lies waiting for his prey like a biologic trap, and takes on the temperature of the swamp in which he lives. This is the result of the low scale of the entire energy system. The alligator has a small brain, thyroid and adrenal glands and heart. The white flesh indicates the limited blood supply. The lion

on the other hand is the most highly energized animal for its size. It excels as a hunter; there is no parallel to the lion's tremedous leap upon its prey. In this animal every organ that deals with the release of energy is large and well developed. A weight for weight comparison shows why the alligator cannot behave like a lion: the alligator has not the equipment.

Different types of birds have different types of energy systems. Poor fliers or nonfliers, such as the Egyptian goose, have less energy utilization and smaller brains than the more active birds of prey. As birds increase in size, so that flying becomes more difficult and infrequent, the energy organs tend to decrease in size. Proportionate weights of the Egyptian goose and of the ostrich offer a striking contrast to those of the fiercely active eagle.

WEIGHTS OF ALLIGATOR AND LION

	Body, Lb.	*Brain, Gm.*	*Thyroid, Gm.*	*Adrenals, Gm.*	*Heart, Gm.*
Alligator	451	14.08	13.32	11.96	318
Lion	430	261	22.52	34.64	1175

The celiac ganglion with its connections, a part of the sympathetic nervous system particularly fitted to speed the release of energy, is more complex in the lion than in any other animal in the world, even man. In the alligator the celiac ganglion is so simple that it can hardly be recognized as the same organ (Fig. 2).

The cat group have smaller brains in proportion to their size than the dog group. This reflects their habits. Cats rely on ambush and a sudden spring to catch their prey, while dogs are geared for the long chase.

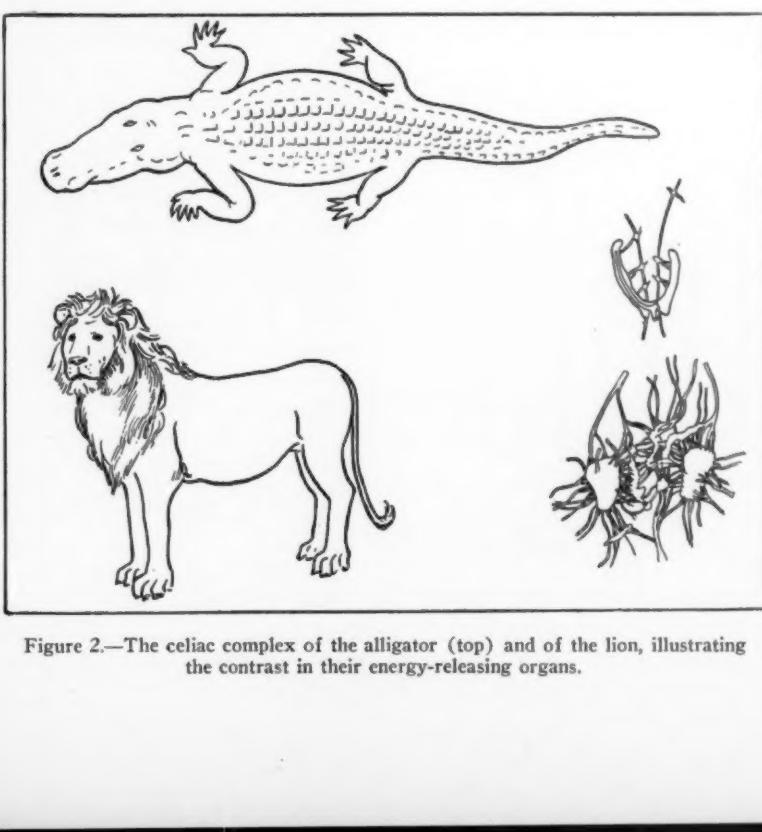

Figure 2.—The celiac complex of the alligator (top) and of the lion, illustrating the contrast in their energy-releasing organs.

WEIGHTS OF EGYPTIAN GOOSE, OSTRICH AND EAGLE

	Body, Lb.	*Brain, Gm.*	*Thyroid, Gm.*	*Adrenals, Gm.*	*Heart, Gm.*
Egyptian Goose	4.62	7.64	0.34	0.42	18.51
Ostrich	270.6	42.11	17.33	23.01	1205
Eagle	3.67	13.11	0.31	0.58	15.7

The grass eaters, such as the beautiful African gazelle (Fig. 3), are protected by

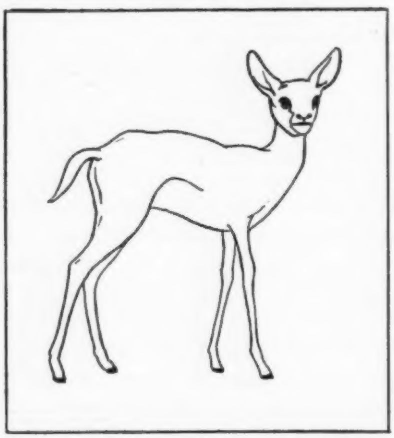

Figure 3.—Young African gazelle; sensitiveness and speed permit swift escape.

delicate sensory organization and great speed from their enemies the carnivores. The corresponding energy equipment includes a large brain, thyroid gland, heart and blood volume to supply the energy needed for the long swift run.

The famous thoroughbred racehorse Equipoise illustrates the effect of artificial selection. The thoroughbred strain represents a cross of the English mare with the Arabian stallion. The result has been early maturity, hardness of bone, alertness, high nervous organization, and most important of all, a large brain and heart. The energy formula is very different from that of a draft or workhorse. The brain of Equipoise was the largest among the 231 horses we examined, and the heart also was extraordinarily large.

Yet the energy equipment of Equipoise was less powerful than that of a white whale of practically the same weight. Since water removes heat from the body much faster than air, a much greater output of energy is needed to maintain the warm-blooded state of a mammal in the sea than on land. Moreover, the white whale must hold its temperature of 98.6 degrees Fahrenheit in the icy waters of the arctic regions.

To test further the concept that the energy-controlling organs are greatly affected by the temperature of the environment, we also studied a sea mammal confined to the tropics, the manatee (Fig. 4).

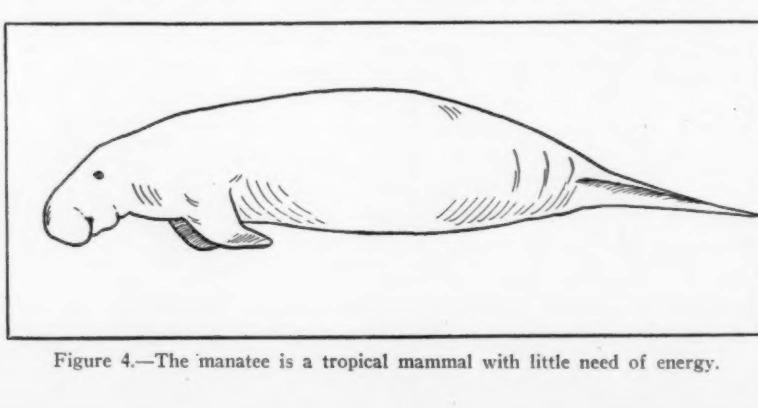

Figure 4.—The manatee is a tropical mammal with little need of energy.

The specimen we investigated weighed about the same as the white whale. Besides needing no protection against cold, the manatee needs no energy for pursuit, as it is a grass eater. It needs no energy for escape, as it has no enemies. It is in fact a sea cow, leading a luxurious life in abundant pastures. This is perfectly illustrated by its small energy system.

Comparing brain size alone, we find that the weight of the brain in relation to body weight steadily increases as we go up the scale of intelligence, power and personality. Among the animals with backbones, the reptile has the lowest proportion of brain and man the highest. The fish ranks above the reptile, probably because of the energy needed by the fish to offset the cooling effect of water even in the cold-blooded state. The whale, being the largest of all animals, has the largest brain in actual size; but man, for his size, is still at the top in brain-body ratio.

WEIGHTS OF RACEHORSE, WHITE WHALE AND MANATEE

	Body, Lb.	*Brain, Gm.*	*Thyroid, Gm.*	*Adrenals, Gm.*	*Heart, Gm.*
Equipoise	1150	808.5	33.40	46.62	4455
White Whale	1148	2355	108	34.76	3181
Manatee	953	351	57.51	Not found	1250

Coming to the most highly organized animals, the primates, we find that all have highly developed brains. This is true of the lemur, an early type of these manlike forms; it is also true of the African monkey, further along in the scale, and of the chimpanzee, which is in many ways closer to man than any other animal. But of all the primates man has by far the largest brain in proportion to body weight.

Another distinguishing feature of man's energy mechanism is a thyroid gland with about two and a half times the weight of the adrenal glands. Other animals, even the manlike apes, have adrenal glands larger than the thyroid gland. This is consistent with the contrasting requirements of wild life and the civilized state. Man has become a thinking, walking animal. His large brain and large thyroid gland fit him for long-continued, uninterrupted activity rather than for the outbursts of energy needed in a crisis.

Comparisons between two species are enlightening, but even more interesting are the trends that emerge in a survey of a number of animal groups.

We have compared the weights of adrenal glands and thyroid gland relative to body weight in vertebrates (Fig. 5).

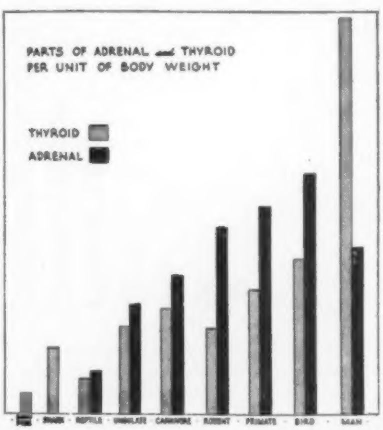

Figure 5.—In contrast to other vertebrates, man is fitted for constant action rather than crisis action.

WEIGHTS OF CHIMPANZEE AND MAN

	Body, Lb.	*Brain, Gm.*	*Thyroid, Gm.*	*Adrenals, Gm.*	*Heart, Gm.*
Chimpanzee	115	440	4.85	8.93	250
Man	170	1450	26.50	11.23	328

This comparison reveals two interesting facts. First, like the brain, the adrenal glands and the thyroid gland become larger with increasing activity and development of the animal species. Second, as previously mentioned, the two adrenal glands together weigh more than the thyroid gland in all animals studied with the exception of man and the whale. This formula, as already noted in the chimpanzee-man comparison, contrasts the outbursts of effort needed for survival in the wild state and the steady, continuous activity of human civilized life.

It is to be expected that the weights of the energy-controlling organs taken together will follow the trend of the individual organs. We have found that their combined weights as compared with body weight increase steadily with the increasing complexity and activity of the various types of animals, from the fish to man (Fig. 6).

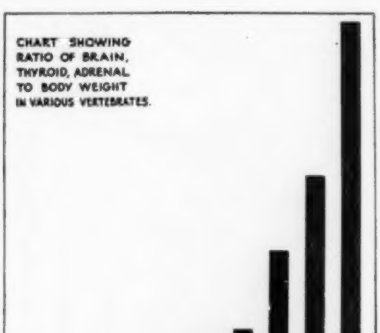

Figure 6.—The increasing proportion of the energy-controlling organs parallels the development of intelligence, power and personality in the animal scale.

In the course of our investigation it became evident that the size of the brain has a direct relation to the amount of energy required to maintain life. We tested this with another comparison, using the figures of a number of investigators in addition to our own. We computed energy output, or basal metabolism as indicated by oxygen consumption, for a large number of animals. We then correlated the figures, expressed in calories, with brain weight. We discovered that regardless of body weight or degree of development, in both cold-blooded and warm-blooded types, each gram of brain stimulates the production of 12,115 small calories in 24 hours. This law holds throughout the animal scale, from the grasshopper and the worm to the elephant (Fig. 7), except for the primates. The fact that the manlike animals and man himself have larger brains than are needed for energy output is simply explained. In these advanced forms a larger part of the brain is required for mind than in the lower animals. The thinking part of the brain added to the simple energy brain raises the total weight of the brain of man to a unique size, in harmony with his unique intelligence, power and personality.

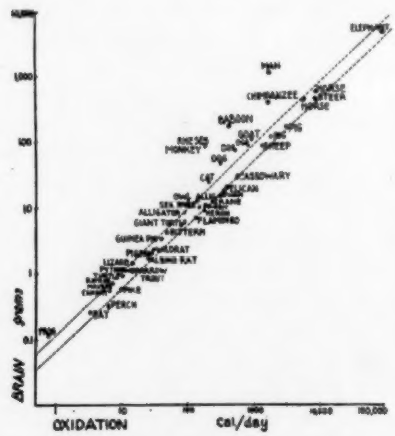

Figure 7.—The "life line", illustrating a portion of the brain-metabolism data. One gram of brain produces 12,115 small calories in 24 hours.

In summary, the results of our research strongly support the idea that the nature and degree of mental and physical activity are determined by the relative and absolute size of the energy-releasing organs. This

conclusion is directly related to the problems of education. For both education and civilization are most highly developed where the energy-controlling system is most highly developed. Geographically, this occurs in regions of bad climate, where the brain, thyroid gland, heart and blood volume must meet the requirements of cold weather, changes in air pressure and sudden electric storms.

But a bad climate, with its rapid and extreme shifts of weather, may cause excessive development of one or another part of the energy system. This may result merely in mental or physical overactivity; or it may lead to one or more of the diseases peculiar to civilized man, such as high blood pressure, exophthalmic goiter, and nervous and mental disorders.

But if these tendencies to overdevelopment are recognized in childhood, they may be prevented from reaching dangerous levels. Horses and dogs can be trained, why not human beings? For instance, the precocious child with an overactive thyroid can be interested in the use of his hands and in other muscular activity rather than in intellectual achievements.

Between the discipline of physical regulation and the discipline of reason, man may learn to understand and control himself and his civilization, by controlling the physical mechanism that made him supreme in the animal world.

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THE LECTURE-DEMONSTRATION VERSUS THE PROBLEM-SOLVING METHOD OF TEACHING A COLLEGE SCIENCE COURSE

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PROBLEM

This study compared the relative effectiveness of a lecture-demonstration method and a problem-solving method of teaching the biological portion of an orientation science course at the college level with respect to achievement on tests constructed to measure (a) recall of specific information, (b) understanding of generalizations, (c) abilities in problem solving and (d) scientific attitudes. The study deals with only the two experimental factors named. It was not concerned with a comparison of the specific teaching procedures * used in

* Teaching procedures are considered here to mean the way in which a specific instructional activity, such as a demonstration, a lecture, or a discussion was used with a group of students.

any one of the two methods nor an evaluation of any plan of organizing subject matter. The retention of final achievement in the four outcomes was not determined.

GENERAL PROCEDURE

Six classes of the biological portion of an orientation science course in the School of Education, New York University,[1] were used as the experimental groups in the investigation. Three classes, consisting of 145 students, were taught by a problem-solving method and three classes, consisting of 137 students, were taught by the lecture-demonstration method. The students enrolled in these courses represented freshmen, sophomores, juniors and seniors, although 67 per cent were juniors and seniors.

The biological portion of the orientation science courses dealt primarily with the problems of human adjustment to the environment of living things. The subject matter of the course was related to six major areas of adjustments:

I. Maintaining Normal Body Functions
II. Protecting Ourselves from Harmful Organisms
III. Transmitting Characteristics to Offspring
IV. Adjusting to Personal Abilities
V. Caring for Living Things
VI. Improving Living Things

The Lecture-Demonstration Method. The lecture-demonstration method, as used in this study, consisted of formal lectures on the subject matter of the course, supplemented by those demonstrations which could be used to illustrate important concepts covered in the lectures. At the beginning of the course, an introductory lecture, presenting an overview of the course, was given those classes working by the lecture-demonstration method. This lecture stressed the meaning of science as a method of solving problems and included a lecture to the students on the elements of problem solving * and the scientific attitude.†

Man's biological environment was described in terms of the living things to which man makes adjustments. An attempt was made in the organization and presentation of this lecture to impress the group with the various kinds of problems man encounters in making adjustments to his biological environment and to organize these into six major problems of adjustment which would constitute the six unit areas ‡ of the course. An attempt was also made to show students how the scientific method could be applied to solving these problems and how the scientific attitude functioned in effective problem solving.

In concluding the lecture, the major objectives of the course were defined for the students, and they were told that an attempt would be made to accomplish these objectives through lectures and demonstrations covering important ideas in the various units.

As the instructor lectured, he outlined on the blackboard the important ideas covered. Upon introducing a unit, he would write the unit problem on the board and present an overview of the important subordinate problems in the unit. These were also copied on the board, and the students were instructed to record this general outline of the unit in their notes. As lectures were presented on each of the subordinate problems, the instructor would outline on

[1] *New York University Bulletin,* School of Education. Announcements for the Session 1939–1940, XXXIX (May 22, 1939). p. 257.

* The elements of problem solving were presented as (1) recognizing the problem, (2) analyzing the problem, (3) formulating hypotheses, (4) gathering data for the solution of the problem, (5) testing the hypotheses, and (6) accepting a conclusion.

† The analysis of the scientific attitude was that which is reported in: Curtis, F. D., *Some Values Derived from Extensive Reading of General Science.* Contributions to Education No. 163. New York: Teachers College, Columbia University, 1924. pp. 48–49.

‡ A unit area, as used in this study, consists of those problems, subject matter and learning activities which are related to a major problem in this biological science course.

the blackboard the major points covered in the lecture. In concluding lectures on each subordinate problem, a generalization covering the problem was organized by the instructor for the class. A generalization covering the entire unit was also presented to the class when each unit was completed.

The demonstrations were presented either by the instructor, or by the graduate assistant, who told the class what was being done and explained those phenomena which were demonstrated. When sound films were used, no additional explanation was given. All silent films, slides and models were interpreted by the instructor. Although students were not encouraged to ask questions, any which they did ask were answered directly.

At the beginning of each new unit, a copy of the bibliography for that unit was given each student. The instructor commented on each of the listed references and students were told that references to the text used for the course were required reading. Students were told that the other references to books, magazines, and pamphlets were listed for those who cared to read beyond the content given in the text.

At the completion of a unit, each student studying was required to prepare a written report on the unit. The reports were to include a record of the important ideas covered in the unit and were to be organized around the subordinate problems which the instructor had included in his lectures. Students were instructed to formulate and record in their reports a generalization that would express the major idea developed in the unit. All reports were read by the instructor, checked for organization, completeness, and scientific accuracy and returned to the students with written comments and a grade attached.

The Problem-Solving Method. The problem-solving method, as used in this study, consisted of those procedures which were planned to encourage student participation in formulating the major problems of the course, analyzing each problem into its specific parts, and proposing and carrying out the various learning activities which would develop understandings of solutions to problems.

Students working by the problem-solving method began their course work by a developmental discussion of the meaning of a general course in biological science. This was initiated by the instructor asking the class what in their opinion this course was supposed to be. There was general agreement that the course, according to their understanding, was a course in biological science. They were then asked for their concept of "science." Responses were varied, and each was written on the board as stated by the students. Generally from twelve to sixteen such statements were copied on the board. The class was then asked to identify an element of definition that was common to all that were on the board. The instructor aided in the development of this by asking questions directed toward the recognition of science as a method of solving problems.

Problem solving was discussed and students were asked to identify the important elements of the process. This resulted in the identification of each of the elements previously referred to. They were then asked if merely doing these things would result in a scientific solution to a problem. It was generally agreed that the person solving a problem had to have a certain attitude or point of view before his solution would be scientific. They were asked to describe this point of view to which we refer as the scientific attitude. All the descriptions were copied on the board, discussed and revised in terms of student criticism.

Similar developmental discussion was used to define "biological" in terms of living things. Students were asked why man was concerned with these living

things. Again this general query was developed through questioning directed to the ideas that man makes adjustments to living things and that these adjustments constitute many problems. They were then asked how their definition of science, as a method of solving problems, and the general idea that man confronts many problems in making adjustments to living things, could be related in a biological science course. After considerable discussion, students with the assistance of the instructor, generally agreed that the course should deal with the ways man solves his problems of adjustment to other living things.

With reference to the previous discussion, the students were asked to formulate what they considered the important objectives of such a course. It was decided that the course should develop their abilities to use the elements of problem solving, should assist them in becoming more scientific in their point of view toward such problems, and help in developing a better understanding of how man adjusts to living things.

The class then developed what they considered the most important adjustments that man makes to living things. In this process, they were asked to identify the living thing to which it was most important that they adjust. After they had recognized themselves as an important living organism to whom they must adjust, they were asked to list the important adjustments they must make to themselves. Many suggestions were given, and with the assistance of the instructor, these were organized around the major adjustments of keeping ourselves "going," having children, and adjusting to our personal abilities. They were then asked to list all the ways in which we adjust to other living things. From the suggestions which were given, three additional adjustments were developed: protecting ourselves from living things, caring for living things, and improving other living things. These six areas of adjustment for living things were set up as the areas in which the unit problems of the course would be formulated.

After this introductory activity, each student was asked to formulate what he considered the most important problem statement in the first unit area. They were asked to write these on paper, after which the instructor asked each of several students to state the problem which he had formulated. Seven or eight of these were copied on the board, and they were asked to select the one which they considered to be the best statement of a problem. They were then asked to list the reasons for their selection. These reasons were listed on the board and organized by the group into several major criteria which could be used to evaluate statements of problems. Each student was instructed to reformulate, in terms of these criteria, his own problem covering the aspect of the unit area which interested him most.

After they had formulated the unit problem, they were asked what should be the next step toward the solution of the problem. This led to an analysis of one of the unit problems which had previously been suggested, and a discussion of the techniques for analyzing such problems. Certain techniques were suggested and applied to the problem. Generally, the analysis of such a problem took about an hour, but in several instances it took two hours of class discussion to satisfy the group that they had brought out all the important aspects of the problem they were analyzing. After this activity, students were told to use whatever suggestions they considered significant from class discussion, add to these any other ideas they had, and work out an analysis of their own statement of the unit problem. It was understood that such an analysis was to be used as a guide to aid them in collecting and organizing information related to their problem.

A copy of the bibliography of reference materials for the first unit area was given each member of the classes studying by the problem-solving method. The references were discussed by students and instructor. Students were told that they would be required to read the reference to their text and that the other references were listed primarily for those who cared to read beyond the material included in the text.

The assistant then described the demonstrations and visual materials, related to the unit area, which were available for class use. Students were encouraged to ask questions about the different materials and to select, as a group, those they felt would aid them most in the solution of the problem. A schedule was prepared by the group for the presentation of these materials in subsequent class periods.

Before demonstrations were presented to the classes, the students were asked to get the purpose of the demonstration clearly in mind. Questions asked by the students were discussed to aid in clarifying their thinking with respect to the purpose of the demonstration. As each demonstration was presented, the demonstrator encouraged students to ask questions concerning any part of the procedure or results obtained which were not clear to them. After each demonstration, they were asked to state the ideas which they had obtained from the demonstration and these were listed on the board. The instructor then helped them formulate a generalization which would express the relationship between these ideas. At first, it was necessary to work through the process of generalizing as a group. As time went on they were given more responsibility for developing the generalizations individually. They all kept a record of the demonstrations in their notes and many of them used these in preparing their written reports on the unit.

The films and slides were used in much the same manner. Before any of the visual materials was shown, students were asked to get clearly in mind the purpose of their observation in relation to the problem upon which they were working, and to keep a record of the ideas they obtained from their observation. In the case of silent films and slides, they were encouraged to ask questions when the material was shown; in the use of sound films, time was taken after the film to clarify any questions. Generalizations based upon the important ideas obtained from each set of slides and each film were formulated after discussion of these visual materials.

Students were required to prepare a written report on each unit area. They were encouraged to formulate the unit problem in terms of the aspect of that area in which they were most interested. Some of the problems would be quite general and comprehensive, others would be rather narrow and limited. Regardless of the problem which they formulated, each student was asked to include in his report a definite statement of his unit problem, an analysis of it, a record of the information he had gathered, and clearly-formulated generalizations. The instructor read each unit report, checked misstatements, criticized the organization and the statements of generalizations, and assigned a grade.

Common Elements. The elements common to both methods included: tests administered to students, bibliographies used by the students, instructor and assistant directing the course, the requirement of a written report of each unit, and the general problem areas of the course.

The Tests Used. Four types of tests were constructed. The tests covering recall of specific information were prepared from various items of information included in the subject matter outline of the course and organized into objective type tests. The tests covering understanding of generalizations were prepared from major generalizations which were considered important outcomes of the course. The items

included in both these types of tests were constructed so that they could be marked and scored objectively.

The tests on abilities in problem-solving covered the abilities to recognize problems, analyze problems, evaluate information, formulate generalizations and evaluate conclusions. Part of the test items included in the problem-solving test could be scored objectively, but other items called for responses from students which could not be scored objectively.

The attitudes tests were constructed by presenting a written description of a problematic situation in which a certain person was confronted with choosing some course of action in meeting the problem. The person taking the test was instructed to write what he would do if he were confronted with such a problem and to give his reasons for such a choice of action. Eight such subjective test situations were used in the attitudes tests.

Before the tests covering the four outcomes were submitted to the students, all test situations and test items were evaluated by a group of qualified jurors. Only those situations and items, which in terms of the jury's evaluation were most suitable, were used in the final construction of tests. Twelve tests were finally constructed, including three tests covering each of the four outcomes.

A battery of four tests, each battery including one test for each of the four outcomes, was administered before the first half of the course started and again after it was completed. Another battery was given before the second half of the course started and again after it was completed. A third battery was administered before the course began and again at the completion of the course.

The objective-type tests covering recall of specific information and those covering understanding of generalizations were further refined by discarding test items which did not distinguish well between the highest and the lowest quarter of all students taking the final test.

Scores on the subjective parts of the problem-solving tests were derived from jurors' opinions concerning the relative significance of individual student's responses to a specific situation.* Scores on the objective items were the total number of correctly marked items. In order to obtain comparable scores on each part of the problem-solving test, a proportion of the average relative weight which jurors had assigned to each part and an equalizing factor were used in multiplying individual scores on each part of the test. These comparable scores were then added to derive the total score on the problem-solving test.

Scores on the attitudes tests were derived from weighted opinions of jurors concerning the extent to which individual student responses showed evidence of the scientific attitude. A test score for each test situation was obtained by adding the weighted values of each response to that situation. The total score on an attitude test for each individual was obtained by adding the scores made on each situation included in that test.

The reliability of the jurors' evaluations of students' responses to the problem-solving and attitudes test situations was obtained by determining the correlation between two evaluations of the same items for each juror. In eighteen of the nineteen test situations, the product-moment coefficients of correlation ranged from .70 to .94, and in the other situation the coefficient of correlation was .57.

The coefficients of reliability for the six objective-type tests were obtained by correlating students' final scores on chance halves of the same test and applying the

* Students' written responses to the various subjective test situations were submitted to jurors for classification into defined categories. Jurors were also asked to weight each category in terms of the significance of that category in representing ability in the element of problem solving with which the test situation dealt.

Spearman-Brown formula.[2] The coefficients of reliability for the three specific-information tests were .43, .68 and .81. The coefficients of reliability for the three generalization tests were .55, .65 and .75.

The coefficients of reliability for the tests covering abilities in problem solving and scientific attitudes were obtained by correlating the scores made by the same students on two administrations of the same tests two weeks apart. The coefficients of reliability obtained for the three problem-solving tests were .67, .53 and .51. The coefficients of reliability obtained for the three attitudes tests were .62, .57 and .55.

Method of Equating Groups. Each of the six pairs of experimental groups was equated by pairing the students in those groups upon two bases, scores on psychological tests[3] and scores on pretests.* In order to render the scores on psychological tests and the scores on a particuluar pretest comparable with one another, the standard score was obtained for each of the raw scores.† The average of the standard score on a pretest and the standard score on the psychologial test was used as the index in pairing students for the purpose of comparing achievement on each final test. Experimental pairs of classes were equated for comparison of achievement on each of the twelve tests used in the study. The statistical significance of differences in mean standard scores for each pair of equated groups was determined.

In eighteen of the twenty-four comparisons the ratios, obtained by dividing the difference between the means of the average standard scores of paired groups by the standard error of the difference,‡ were less than one. In six of the twenty-four comparisons, the ratios obtained were greater than one but in none of these was the ratio greater than 1.45.

Comparisons of results on final tests were made for the entire group of students included in each experimental pair of classes; for three intelligence-level groups * of students included in each experimental pair of classes; and for the three background-level groups † of students included in each experimental pair of classes. These comparisons were made for each of the four types of tests, recall of specific information, understanding of generalizations, abilities in problem solving and scientific attitudes. The statistical significance of differences in means on final tests for each pair of equated classes was determined, although the number included in each of the three ability levels compared was too small to justify the determination of the significance of obtained differences.

THE FINDINGS

The mean pretest scores for each pair of equated classes on each of the twelve tests used in this study were compared and the statistical significance of differences determined. Out of the twenty-four comparisons made, there were only four cases in which the ratio obtained by dividing the differences in means by the standard error of the difference was greater than 1.0.‡

[2] Odell, Charles W. *Statistical Method in Education.* New York: D. Appleton Century Company, 1925. p. 210.

[3] Thurstone, L. L., and Thurstone, Thelma Gwinn. *American Council on Education Psychological Examination for College Freshmen.* Washington: The American Council on Education, 1939.

* Scores obtained on tests administered before the periods of instruction.

† The following formula was used in deriving the standard scores:

$$\frac{50 + 10\,(X - M)}{\sigma}$$

‡ These ratios were determined by using the following formula:

$$\sigma D = \sqrt{\sigma M_1^2 + M_2^2 - 2r_{12}\,\sigma M_1\,\sigma M_2}$$

* Refers to groups of students who ranked in the highest quarter, middle half and lowest quarter on the psychological tests.

† Refers to groups of students who ranked in the highest quarter, middle half and lowest quarter in terms of pretest scores.

‡ The formula used was

$$\sigma D = \sqrt{\sigma M_1^2 + M_2^2 - 2r_{12}\,\sigma M_1\,\sigma M_2}$$

The ratios in the other comparisons ranged from 0 to 1.0.

The differences between mean pretest score and mean final test score on each of the twelve tests was determined for each experimental class, as well as the statistical significance of differences. In all comparisons made, there were only two cases in which the mean increment from pretest score to final-test score was not sufficiently large to assure that in at least 98 chances out of 100 the differences would be significant.

The data included in Table I deal with a comparison of the mean achievement of equated groups on final tests covering recall of specific information. These data show that all classes taught by the lecture-demonstration method made higher mean scores than equated classes taught by the problem-solving method. These differences ranged from .74 to 3.71 score points, with three out of six greater than 2.3. In three of the comparisons made in Table I, the ratio obtained by dividing the difference in means by the standard error of the difference was greater than 2.3. The others ranged from .66 to 1.2.

The evidence obtained from tests covering recall of specific information showed the lecture-demonstration method, in 15 out of 18 comparisons, realized greater mean gains among the students ranking in all three intelligence levels. Mean gains in favor of the lecture-demonstration method were greatest among the students ranking in the lowest quarter and least among the students ranking in the middle

TABLE I

COMPARISON OF THE MEAN FINAL-TEST SCORES OF THE EQUATED CLASSES ON THE SPECIFIC INFORMATION TESTS

Test No.	Class [1]	Instructional Method	No. Students	Mean	S.D.	Diff.	$\frac{\text{Diff.}}{\sigma\text{diff.}}$	Method Having Advantage
1	014.7, 8(1)	L.D.[2]	30	25.13	6.82	1.66	1.20	L.D.
	014.7, 8(2)	P.S.[3]	30	23.47	5.28			
1	014.7, 8(W)	L.D.	22	25.27	6.44	3.71	2.36	L.D.
	014.7, 8(M)	P.S.	22	21.56	5.95			
2	014.7, 8(1)	L.D.	28	10.85	3.16	.74	1.09	L.D.
	014.7, 8(2)	P.S.	28	10.11	3.05			
2	014.7(W)	L.D.	35	13.14	3.61	2.34	2.57	L.D.
	014.7(M)	P.S.	35	10.80	3.41			
3	014.7, 8(1)	L.D.	29	13.41	4.95	.96	.66	L.D.
	014.7, 8(2)	P.S.	29	12.45	4.38			
3	014.8(W)	L.D.	39	14.82	4.74	3.25	3.49	L.D.
	014.8(M)	P.S.	39	11.57	3.56			

[1] The 014.7, 8(1) Class completed the course the first semester.
The 014.7, 8(2) Class completed the course the second semester.
The 014.7, 8(W) Class met on Wednesday and completed the course in two semesters.
The 014.7, 8(M) Class met on Monday and completed the course in two semesters.

[2] L.D. indicates Lecture-demonstration method.

[3] P.S. indicates Problem-solving method.

half. Because of the small number of students in each intelligence-level group, the statistical significance of differences were not determined.

Out of the 18 comparisons which were made between the three background-levels, the lecture-demonstration method realized greater mean gains, on tests covering recall of specific information, in 17 comparisons. The mean gains in favor of the lecture-demonstration method were greatest among students ranking in the lower quarter and least among students ranking in the upper quarter. The statistical significance of these differences was not determined because the number of students included in each group was too small.

As reported in Table II, a comparison of the mean achievement of equated groups on final tests covering understanding of generalizations showed that, in all but one case, the classes studying by the problem-solving method made better gains. These differences in means ranged from .28 to .80 test score points. In no case was the difference in means sufficiently great to be considered statistically significant. The mean gains in favor of the problem-solving method were greatest among students ranking in the lower quarter on psychological tests, whereas the mean gains of students ranking in both the upper quarter and middle half showed no marked differences in favor of either method. Students ranking in the upper quarter and middle half, on pretest covering understanding of generalizations, achieved greater gains by the problem-solving method, although the

TABLE II

COMPARISON OF THE MEAN FINAL-TEST SCORES OF THE EQUATED CLASSES ON THE UNDERSTANDING OF GENERALIZATIONS TESTS

Test No.	Class [1]	Instructional Method	No. Students	Mean	S.D.	Diff.	Diff. / σdiff.	Method Having Advantage
1	014.7,8(1)	L.D.[2]	30	22.60	4.10	.28	.29	P.S.
	014.7,8(2)	P.S.[3]	30	22.88	4.95			
1	014.7,8(W)	L.D.	19	23.84	4.24	1.68	1.34	L.D.
	014.7,8(M)	P.S.	19	22.16	4.60			
2	014.7,8(1)	L.D.	32	9.62	2.54	.60	1.05	P.S.
	014.7,8(2)	P.S.	32	10.22	2.08			
2	014.7(W)	L.D.	36	8.67	2.76	.37	.53	P.S.
	014.7(M)	P.S.	36	9.04	2.60			
3	014.7,8(1)	L.D.	30	14.27	3.91	.80	1.18	P.S.
	014.7,8(2)	P.S.	30	15.07	3.76			
3	014.8(W)	L.D.	35	15.34	2.39	.68	1.33	L.D.
	014.8(M)	P.S.	35	14.66	2.78			

[1] The 014.7,8(1) Class completed the course the first semester.
The 014.7,8(2) Class completed the course the second semester.
The 014.7,8(W) Class met on Wednesday and completed the course in two semesters.
The 014.7,8(M) Class met on Monday and completed the course in two semesters.
[2] L.D. indicates Lecture-demonstration method.
[3] P.S. indicates Problem-solving method.

differences were small and the statistical significance of the differences was not determined.

As reported in Table III, all classes taught by the problem-solving method made higher mean scores on tests covering abilities in problem solving than the classes taught by the lecture-demonstration method. These differences ranged from 8.89 to 24.96 test score points, and in five of the six comparisons the differences were sufficiently great to insure practical certainty of being significant differences.

Students ranking in each of the three intelligence-levels made greater mean gains, on tests covering abilities in problem-solving, by the problem-solving method than paired students studying by the lecture-demonstration method. The differences in mean gains in favor of the problem-solving method were greater for those students ranking in the middle half and lower quarter on psychological tests. In comparing the mean gains of students ranking in the three levels of achievement on pretests, it was found that, in all three levels, greater mean gains were made by students taught by the problem-solving method. Since the number of students, included in the comparisons of achievement of the various ability and background-levels, was small, no attempt was made to determine the statistical significance of these differences.

Comparisons of the achievement of equated groups on the tests covering sci-

TABLE III

COMPARISON OF THE MEAN FINAL-TEST SCORES OF THE EQUATED CLASSES ON THE PROBLEM-SOLVING TESTS

Test No.	Class [1]	Instructional Method	No. Students	Mean	S.D.	Diff.	Diff. / σdiff.	Method Having Advantage
1	014.7, 8(1)	L.D.[2]	32	195.94	33.02	24.96	3.94	P.S.
	014.7, 8(2)	P.S.[3]	32	220.90	33.11			
1	014.7, 8(W)	L.D.	20	193.50	27.11	22.00	2.23	P.S.
	014.7, 8(M)	P.S.	20	215.50	28.57			
2	014.7, 8(1)	L.D.	25	111.30	18.20	17.40	4.53	P.S.
	014.7, 8(2)	P.S.	25	128.70	15.20			
2	014.7(W)	L.D.	27	122.31	25.70	8.89	1.79	P.S.
	014.7(M)	P.S.	27	131.20	18.55			
3	014.7, 8(1)	L.D.	30	168.33	21.49	21.00	2.94	P.S.
	014.7, 8(2)	P.S.	30	189.33	24.11			
3	014.8(W)	L.D.	37	165.27	17.32	24.42	4.86	P.S.
	014.8(M)	P.S.	37	189.69	25.94			

[1] The 014.7, 8(1) Class completed the course the first semester.
The 014.7, 8(2) Class completed the course the second semester.
The 014.7, 8(W) Class met on Wednesday and completed the course in two semesters.
The 014.7, 8(M) Class met on Monday and completed the course in two semesters.

[2] L.D. indicates Lecture-demonstration method.

[3] P.S. indicates Problem-solving method.

entific attitudes, as reported in Table IV, show that all classes taught by the problem-solving method achieved higher mean scores than classes taught by the lecture-demonstration method. These differences ranged from 5.56 to 12.19 test score points and in five of the six comparisons made, there was practical certainty that the obtained differences represent true differences.

In all but one case, students ranking in the three intelligence-levels made greater gains on tests covering scientific attitudes by the problem-solving method than paired students who studied by the lecture-demonstration method. In all but one case, students ranking in each of the pretest-achievement levels made greater gains by the problem-solving method on tests covering scientific attitudes. The statistical significance of gains was not determined.

CONCLUSIONS

In comparing this problem-solving method with this lecture-demonstration method of teaching this biological science course to this group of students, when comparisons are based upon the tests used in this study, several conclusions seem reasonable and justifiable.

1. The lecture-demonstration method has some advantages over the problem-solving method with respect to

TABLE IV

COMPARISON OF THE MEAN FINAL-TEST SCORES OF THE EQUATED CLASSES ON THE ATTITUDES TESTS

Test No.	Class [1]	Instructional Method	No. Students	Mean	S.D.	Diff.	$\frac{\text{Diff.}}{\sigma\text{diff.}}$	Method Having Advantage
1	014.7, 8(1)	L.D.[2]	27	43.26	11.75	11.70	3.32	P.S.
	014.7, 8(2)	P.S.[3]	27	54.96	20.00			
1	014.7, 8(W)	L.D.	16	33.44	10.75	12.19	3.87	P.S.
	014.7, 8(M)	P.S.	16	45.63	12.25			
2	014.7, 8(1)	L.D.	25	19.02	9.27	6.48	2.65	P.S.
	014.7, 8(2)	P.S.	25	25.50	9.96			
2	014.7(W)	L.D.	31	23.14	8.58	7.55	3.00	P.S.
	014.7(M)	P.S.	31	30.69	8.94			
3	014.7, 8(1)	L.D.	27	18.43	12.50	10.18	3.29	P.S.
	014.7, 8(2)	P.S.	27	28.61	10.40			
3	014.8(W)	L.D.	32	15.50	6.58	5.56	3.07	P.S.
	014.8(M)	P.S.	32	21.06	11.28			

[1] The 014.7, 8(1) Class completed the course the first semester.
The 014.7, 8(2) Class completed the course the second semester.
The 014.7, 8(W) Class met on Wednesday and completed the course in two semesters.
The 014.7, 8(M) Class met on Monday and completed the course in two semesters.
[2] L.D. indicates Lecture-demonstration method.
[3] P.S. indicates Problem-solving method.

achievement on tests covering specific information, although the results in all cases are not statistically significant.

2. Neither method has statistically significant advantages over the other with respect to achievement on tests covering the understanding of generalizations.
3. The problem-solving method has statistically significant advantages over the lecture-demonstration method with respect to achievement on tests covering certain abilities in problem solving.
4. The problem-solving method has statistically significant advantages over the lecture-demonstration method with respect to achievement on tests dealing with scientific attitudes.

RECOMMENDATIONS

In the light of the findings of this investigation certain recommendations are indicated as follows:

1. The procedures used in this problem-solving method suggest ways in which learning activities can be conducted in the classroom to realize greater achievement in problem-solving abilities and scientific attitudes.
2. Because this investigation was limited to a general study of the relative effectiveness of two methods with respect to achievement in four different outcomes, a more intensive study of certain of these outcomes might provide evidence concerning the effect that various factors have upon the development of behavior with which those outcomes deal.
3. The techniques used in this study for measuring abilities in problem solving and possession of scientific attitudes could be further refined and used as more accurate instruments for measuring these outcomes.
4. Since this study revealed no distinct advantages in favor of either method upon student achievement in understanding generalizations, further study should be made of the more fundamental elements involved in understanding generalizations.
5. Because no previous studies have been reported in which problem-solving and attitudes tests of the type used in this study were used, it is recommended that further studies be made using tests of higher reliability for measuring these learning outcomes.

THE RCA ELECTRON MICROSCOPE *

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Direct observation of extremely minute objects is of great value to both science and industry. Consequently a great deal of time and effort has been spent developing and perfecting optical instruments for making such observations. The modern light microscope is capable of rendering visible detail which is as fine as 0.00002 centimeter. Since the limit of resolving power of the normal eye is between 0.01 and 0.02 centimeter, the maximum useful magnification with these instruments is 1,000 to 2,000 diameters. Where ultraviolet light is used,

* Extracted from "An Electron Microscope for Practical Laboratory Service" by V. K. Zworykin, J. Hillier, and A. W. Vance, RCA Laboratories. Published in *Electrical Engineering*, Vol. 60, No. 4, *Trans.* pp. 157–161.

the useful magnification can be increased to about 3,000 diameters.

The limits discussed above are not due to imperfections in the optical systems or lenses, but are fundamental in nature. It has been shown quite generally that diffraction effects at the object determine the least separation between points or lines on the object which can be resolved. On the basis of this limitation, the resolving power (for lines) at the object is given by

$$d = \frac{0.5\ \lambda}{\mu\ \sin\ \alpha}$$

where λ is the wavelength of the radiation illuminating the object; μ the index of refraction of the medium in which the object is imbedded, and α the half angle of the cone of light entering the optical system. For visible light the smallest wavelength is about 4,000 Angstrom units, and the maximum index for the fluid immersing the object is 1.7; therefore, since sin α cannot be greater than unity, the minimum distinguishable distance is seen to be about 1,200 Angstrom units.

From the foregoing it is evident that to extend the range of observation it is necessary either to find an immersion substance which has a very much greater index of refraction, or to illuminate the object with rays having a much shorter wavelength. No known optical medium has an index of refraction greater than two or three, and no liquid suitable for use with an immersion objective has an index greater than the figure used above, namely, 1.7. Therefore, there is little hope of achieving high resolution in this direction. Electromagnetic radiation in the form of X-rays and gamma rays has a wavelength much shorter than that of visible and ultraviolet light used at present in microscopy. However, due to the fact that lenses or reflectors cannot be made for this portion of the spectrum, advances in this direction are also barred.

For many years the problem of observing appreciably finer detail appeared to be incapable of solution. The search, however, had been restricted almost entirely to the realm of optics, whereas actually the solution lay in an entirely different field—electronics. A little less than 15 years ago it was found that the path of electrons in electric and magnetic fields could be described in terms which are analytically equivalent to those of optics. By means of this electron optical equivalence, it was shown that axially symmetric electric or magnetic fields had the properties of optical lenses, and, consequently, that it is possible to form electron images in the same way that light images can be formed.

At about the same time, the discovery was made that any material particle in motion had associated with it a characteristic wavelength. For electrons this wavelength, in terms of their velocity expressed in electron volts, is given by the following relation:

$$\lambda = \sqrt{\frac{150}{V}} \text{ Angstrom Units}$$

On the basis of the equation, electrons moving with a velocity corresponding to 60 kv have an effective wavelength of 0.05 Angstrom unit, or only about 1/100,000 that of light. In other words, suitably designed electronic systems employing these high-speed electrons should be capable of extremely high resolving power.

These two concepts led directly and logically to the idea of an electron microscope based on the same principles used in an optical microscope. Such an instrument employs condenser, objective, and projection lenses, performing the same functions as the corresponding elements in the light microscope, but the lenses, instead of being made of glass are formed by axially symmetric electric or magnetic fields. The fundamental similarity between an ordinary compound light microscope and an electron microscope is illustrated by the simplified diagrams in Figures 1-A and 1-B.

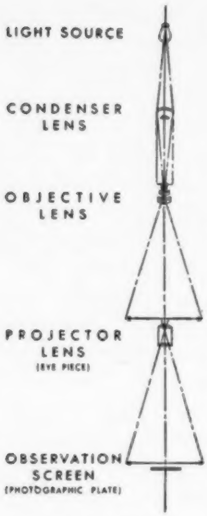

Figure 1-A.—Compound Light Microscope.

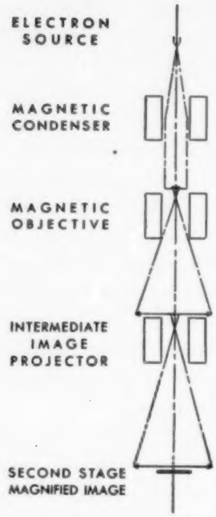

Figure 1-B.—Electron Microscope.

During the past ten years instruments of this type have been investigated in detail in various parts of the world. As a result, the electron microscope has been developed to a point where it is capable of a useful magnification nearly two orders of magnitude greater than the ordinary light microscope. Until recently, the development has been in the hands of physicists, and the instruments built were designed almost entirely for the purpose of studying the microscope itself. However, the microscope has now progressed beyond this stage, and has become a research tool of great potential value.

Figure 2 is a photograph of the complete microscope. The unit includes not only the microscope itself, but also the regulated power supplies providing the 60-kv overall voltage and the current for the three magnetic lens coils. The oil diffusion pump for maintaining the required vacuum within the instrument is also contained in the unit.

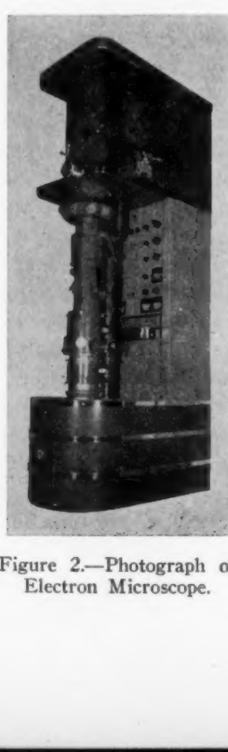

Figure 2.—Photograph of Electron Microscope.

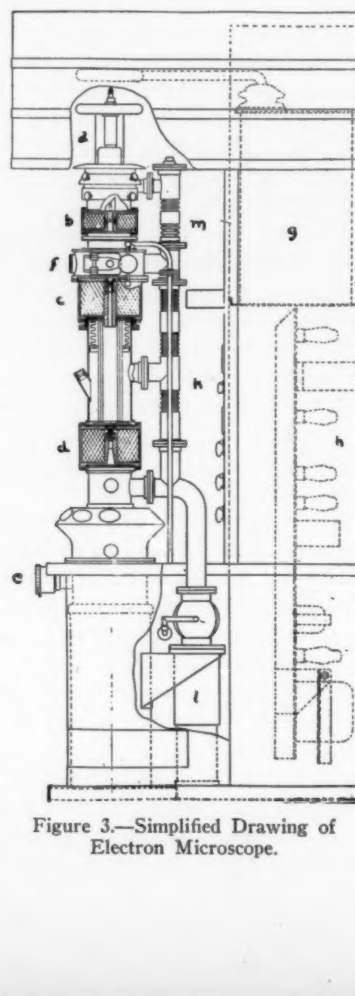

Figure 3.—Simplified Drawing of Electron Microscope.

A simplified drawing is given in Figure 3, which shows the construction of the microscope. The electrons used in the imaging process are supplied from the electron gun (a), containing a thermionic cathode which is maintained at 60 kv negative with respect to ground, and a final anode at ground potential. Between the two are disposed the electrodes required for governing the electron paths. The electrons leaving the gun have their full velocity, corresponding to 60 kv.

The condenser lens (b), which consists of an iron-clad coil with pole pieces shaped to give the required magnetic field, causes the electrons to converge upon the specimen held a few centimeters below it. The condenser, like the condenser lens of a light microscope, can be used to control the angular aperture of the illumination at the specimen.

After passing through the specimen, the electrons enter the objective lens (c). This lens deflects the electrons leaving the specimen in such a way as to focus them into a magnified intermediate image of the specimen. This image is formed directly above the projection lens (d). The objective, like the condenser, is an armored coil, but the pole pieces are, of course, different in design to meet the requirements of this element.

The final image is formed from the portion of the intermediate image which passes through the projection lens (d) and is re-imaged in the plane of the observing screen or photographic plate at (e). The magnification of the intermediate image is about 100 diameters, and the magnification by the projection lens can be varied between 20 and 300 diameters; therefore the total magnification can be controlled over the range between 2,000 and 30,000 diameters. The maximum electronic magnification of the microscope is two or three times less than the greatest useful magnification corresponding to the resolving power of the instrument, the full useful magnification, for reasons that are discussed below, being obtained by additional photographic enlargement. When visual observation of the specimen is required, the final image is allowed to fall on a fluorescent screen. This screen can be raised out of the way to permit the image to impinge upon a photographic plate for a permanent record, or for more detailed examination.

Since electrons will not travel freely through air, the entire electron optical path of the microscope must be under vacuum, that is, at a pressure of about 10^{-5} mm. Hg. If it were necessary to repump the entire microscope every time a specimen or photographic plate is changed, it would greatly curtail the speed of operation of the instrument. Consequently "air locks" are provided which permit making these changes without breaking the vacuum. The photographic chamber is arranged with a similar air lock. The photographic plate used with the microscope is about ten by two inches in size. The long plate permits making a number of exposures on the same plate. An adjustable mask governs the width of the picture.

The microscope pumping system consists of a three-stage oil diffusion pump (1), in Figure 3, which is connected to the main chamber of the instrument through the manifold (m). This pump is backed up by a mechanical fore pump. A second auxiliary mechanical pump is used to exhaust the two air lock chambers.

It can be shown that the focal length of a magnetic electron lens depends upon the current through the lens coil and the velocity of the electrons themselves. This means that the high-voltage supply and the lens current sources must be very free from fluctuations. In order to obtain a resolving power of 10^{-7} centimeters it is found that the following stabilities are required:

Over-all microscope voltage	— 0.015	per cent
Objective current	— 0.0075	per cent
Projection lens current	— 0.068	per cent
Condenser lens current	— 0.1	per cent

The problem of obtaining 60 kv with the required degree of constancy in the small space available is both difficult and interesting. The high-voltage supply, which was designed by A. W. Vance, employes radio-frequency power rather than the conventional 60-cycle power to actuate the step-up transformer unit. This results in a number of advantages. A low-loss resonant coil can be used which occupies only a small volume and requires only a small exciting power. Much smaller condensers can be used for a given allowable amount of ripple. A regulator operating on the low-voltage side of a rectifier is limited in its speed of regulation by the frequency of the power supplied. At radio frequency this limitation becomes unimportant. Finally, stray fields, which are difficult to shield at 60 cycles, are easily shielded when radio frequency is used. It is, therefore, possible to mount the power supply close to the microscope as an integral part of the unit.

The high-frequency ripple is eliminated from the high-voltage output by means of a tuned filter. Low-frequency disturbances are removed by comparing a fraction of the output voltage obtained from a special divider with a standard voltage, and controlling the oscillator screens by means of a d-c amplifier. Such a feedback regulator, when certain necessary precautions are effected, is capable of extreme constancy. The measured voltage fluctuation over a period of 30 minutes is less than 0.002 per cent in the actual microscope power supply.

The current supplies for the three lens coils are controlled by very sensitive regulators. These regulators make use of well known principles and will not be discussed here. By careful design and the use of a number of special refinements, these current sources have a constancy of better than 0.002 per cent for the objective lens, 0.004 per cent for the projection lens, and 0.02 per cent for the condenser lens.

The operation of the instrument is simple in the extreme. The operator seated in the observers' position can reach the electrical controls and thus adjust overall voltage, magnification, or focus, while watching the image. In addition, the specimen can be moved in two directions in a horizontal plane, so that any portion of the object may be brought into the field of the microscope. Six ports are provided for viewing the final image, and, in order to permit initial orientation of the specimen, three small windows allow direct observation of the low-magnification, intermediate image.

To record the image photographically, it is only necessary to move the plate into position under the fluorescent screen, and then to raise the screen so that the electron image falls on the plate. The fluorescent screen is designed to serve as the shutter for timing the exposure. It is expedient when making electron micrographs to use as low an electronic magnification as possible, and to obtain the full useful magnification by photographic enlargement of the plates. In general, a photographic enlargement of six to ten times can be made without bringing out the grain of the emulsion. Therefore, if the total useful magnification required is 100,000 diameters, the electronic magnification will be 10,000 to 16,000. The advantages of this procedure are that it decreases the exposure time, reduces the bombardment to which the object must be submitted, and increases the useful field of view of the microscope.

The specimens themselves are mounted somewhat differently from those used with a light microscope. Glass slides would be completely opaque to electrons; therefore the objects to be examined are mounted on extremély thin cellulose films, supported by a fine wire mesh. The method of preparing one of these supporting films, which are only about 0.000001 centimeter thick, is to drop collodion on water and allow it to

spread out. The material or particles to be studied are usually suspended in water or some other suitable liquid, and a drop of the suspension is placed on the film. After the liquid has evaporated, the specimen is ready for use.

The utility of this instrument is almost unlimited, and it finds applications in many fields of scientific and industrial research. Two fields, chosen at random, serve to illustrate its value. In bacteriology and biology it opens up new and entirely unexplored realms, for with this microscope microorganisms such as viruses, which cannot even be seen with an optical instrument, can be studied in detail. Figure 4 is a typical micrograph of human tuberculosis. Much of the structure seen in this photograph is well below the resolving power of an ordinary microscope. In physical chemistry it can be used to study colloids, point reactions, the structure of thin films, and even large organic molecules. To illustrate this application, micrographs of a slightly polymerized vinyl chloride film is shown in Figure 5.

Figure 4.—Micrograph of Human Tuberculosis, magnification reduced in in reproduction to 13,500 diameters from original micrograph of 45,000 diameters.

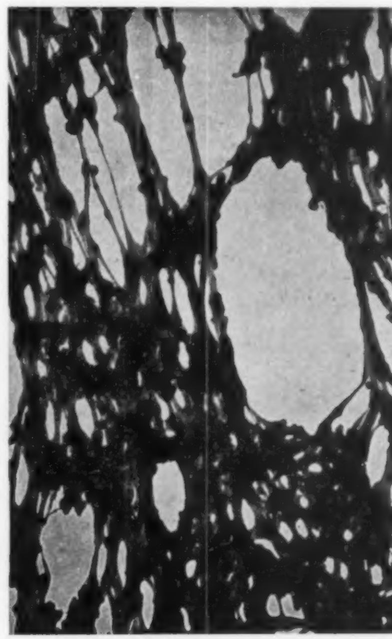

Figure 5.—Micrograph of Slightly Polymerized Vinyl Chloride, magnification reduced in reproduction to 23,000 diameters from original micrograph of 60,000 diameters.

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SCIENCE IN THE NEWSPAPER *

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A question which is constantly raised by teachers and others interested in education is "what should be taught?" Since the volume of human learning is almost beyond comprehension, educators must constantly select that which is thought to be most fundamental and indispensable.

This problem of selection of content exists in a relatively acute form in the field of natural science. Under this head are found such specialized branches as botany, horticulture, agriculture, paleontology, medicine, physiology, geology, astronomy, anthropology, cytology, chemistry, spectroscopy, and meteorology. Other specialized fields can readily be added.

In this so-called scientific age, most thinking individuals agree that instruction in science should play a significant part in the program of the schools. Obviously not all of the specialized sciences can be taught. The question to be answered is, "What and how much of each of the many sciences should be taught to the average person who is not a science specialist?"

In many secondary schools, instruction in general science for all students is increasing rapidly. In colleges the usual requirement has been the taking of a certain minimum of work in one of the specialized sciences. One criticism of the collegiate plan has been that the non-science specialist, in taking intensive work in only one branch of science, lacks comprehension of the entire field. There have been increasing of late "integrated," "survey," and "general science" courses in colleges.

In reply to the question as to what should be included in science instruction for the non-specialist, it frequently has been suggested that analyses be made of what people generally read, such as newspapers, popular periodicals, and popular books.

As an outgrowth of these suggestions, the writer decided to make a study of a representative newspaper with respect to its science content. It should be strongly emphasized that such a study in itself is not considered to be the sole determiner in constructing a course of study in science, but it should have weight.

It was planned in this study to determine the kind, amount, and rate of change of science material in the New York Times over a period of years.

Although many investigators have analyzed popular literature, some of the most extensive and significant work has been done by Bobbitt [1] and his associates. They sought to determine the "general fields of human action" by comprehensive analyses of the Literary Digest, the ten thousand most frequently used English words (taken from Thorndike's "Teacher's Word Book"), The Encyclopedia Britannica, the Reader's Guide to Periodical Literature, the index of the New York Times, and other fields of literature.

Newspapers and periodicals have been analyzed for their science content by a number of investigators. Most of the studies, however, have been decidedly limited in scope and significance. Finley and Caldwell,[2] about twenty years ago, meas-

* Based upon one part of a doctorial dissertation, entitled "An Analysis of the Science Content of the New York Times and of Selected General Science Textbooks," Temple University, 1942.

[1] Bobbitt, Franklin. *Curriculum Investigations.* Chicago, Illinois: The University of Chicago, 1926.

[2] Finley, Charles W., and Caldwell, Otis W. *Biology in the Public Press.* New York: Lincoln School of Teachers College, 1923. (From Francis D. Curtis. *A Digest of Investigations in the Teaching of Science.* P. Blakiston Son and Company, 1926, pp. 259–264.)

ured and classified the biology in selected urban and rural newspapers. Curtis,[3] in 1924, basing his work in part on the newspaper articles of Finley and Caldwell, investigated the scientific knowledge required for an intelligent reading of the public press.

In the present study, it was at first planned to analyze and compare the science content of several newspapers over a ten-year period. It soon became apparent, however, that the task would be too extensive. For this reason it seemed advisable to limit the investigation to a more intensive study of one newspaper. The New York Times was chosen because of its large numerical and geographical circulation, and its wide recognition for intrinsic worth.

The issues over four years were analyzed completely. The years selected for study were 1930, 1933, 1936, and 1939. Every page of each paper was scanned, including the special departments of the Sunday edition. Omitted were advertisements, daily weather maps (introduced in 1934), daily weather forecasts, and crop reports. In all, forty-eight months, or 1,461 newspaper issues were studied, covering a total of an estimated minimum of 75,000 pages.

The analysis was not limited to articles devoted strictly to science, but included also those devoted only in part to it. The length of the scientific reference was measured in column-inches and recorded on an index card. In order to eliminate passing references, such as names of diseases, the writer adopted an arbitrary minimum of one-half column-inch for inclusion of any reference. The analysis was detailed, one article often being separated into several elements, depending upon its content. A singe article on a medical subject, for example, might include a description of a disease, information on the chemical synthesis of specific drugs, and an outline of the preparation of vaccines. Thus the article would not be recorded as one unit, but its length would be divided among the respective fields indicated.

Only that part of the article or reference was measured which met the subjective criterion of being material which was likely to be found in a science textbook or reference book. If it had not been for this restriction, it is likely that material on weather, for example, would have been most voluminous in the completed analysis, instead of its occupying a position of moderate importance. It was considered preferable in measuring, therefore, to delete unrelated material of a political and circumstantial nature, despite the consequent necessity of having to introduce the factor of subjective estimate.

As a check upon the reliability of the study, three months were selected at random from the forty-eight months in the complete newspaper analysis, and these three months were analyzed completely and independently for a second time. The months chosen were August, 1933, January, 1936, and May, 1939. The deviations in volume between the first and second analyses averaged three and seven-tenths per cent. It would seem reasonable on this basis to assume the analysis to be reliable within the limits indicated by this check.

The completed analysis resulted in a total of approximately 375 topics, some of which were later combined, giving a final total of 185 topics. The 185 topics were classified into fifteen major-topics for purposes of study and comparison.

In attempting to determine the fifteen major-topics, many science textbooks were examined for their chapter names, unit organization, and the like. The classification as finally made, however, was suggested chiefly by the nature of the newspaper science.

[3] Curtis, Francis Day. *Some Values Derived from Extensive Reading of General Science.* Contributions to Education, No. 163. New York: Teachers College, Columbia University, 1924, pp. 10–27.

The major-topics, with the newspaper volumes by years, are shown in Table I. As indicated in this table, 52,238 column-inches of space were devoted to science during the four complete years of the New York Times analyzed. The total volume found in 1930 was approximately the same as in 1936. The volume in 1933 was less than in either of the years mentioned. The volume for 1939 was smallest, being approximately thirty per cent less than in 1930, the year for which the maximum was recorded. Whether or not this falling off in volume during 1939 was significant, is problematical. It may be a fluctuation and not indicative of a trend.

For comparisons of trends within the various major-topics, as well as other analyses, it seems preferable to compare proportions of volumes, rather than absolute amounts of newspaper space. For this reason, Table II, indicating the per cent of the total space devoted to each major-topic, is presented.

TABLE I

NEWSPAPER VOLUMES IN COLUMN-INCHES FOR MAJOR-TOPICS DURING THE YEARS 1930, 1933, 1936, 1939 IN NEW YORK TIMES

Major-Topic	*1930*	*1933*	*1936*	*1939*	*Totals*
1. Health and Medicine	2,839	2,550	3,133	1,965	10,487
2. Communication and Transportation	1,816	942	1,012	757	4,527
3. Animal Life	1,428	1,098	1,064	662	4,252
4. Man and Behavior	1,289	982	993	592	3,856
5. Gardening and Agriculture	406	440	1,743	1,027	3,616
6. Earth Science	1,287	979	584	563	3,413
7. Weather and Forecasting	796	806	1,161	619	3,382
8. Applied Chemistry	674	614	722	1,163	3,173
9. Atomic Investigation, etc.	834	886	873	478	3,071
10. Astronomy	1,032	719	548	545	2,844
11. Forms of Energy, Applications	645	715	552	624	2,536
12. Conservation	492	594	854	269	2,209
13. Plant Life	591	373	639	375	1,978
14. Principles of Chemistry	428	387	478	503	1,796
15. Mechanics	355	247	241	255	1,098
Totals	14,912	12,332	14,597	10,397	52,238

TABLE II

PER CENT OF TOTAL NEWSPAPER SCIENCE VOLUME DEVOTED TO EACH MAJOR-TOPIC DURING 1930, 1933, 1936, 1939 IN NEW YORK TIMES

Major-Topic	*1930*	*1933*	*1936*	*1939*	*Total*
1. Health and Medicine	19.0	20.7	21.5	18.9	20.1
2. Communication and Transportation	12.2	7.6	6.9	7.2	8.7
3. Animal Life	9.6	8.9	7.3	6.4	8.1
4. Man and Behavior	8.6	8.0	6.8	5.7	7.4
5. Gardening and Agriculture	2.7	3.6	11.9	9.9	6.9
6. Earth Science	8.6	7.9	4.0	5.4	6.5
7. Weather and Forecasting	5.3	6.5	8.0	6.0	6.5
8. Applied Chemistry	4.5	5.0	4.9	11.2	6.1
9. Atomic Investigation, etc.	5.6	7.2	6.0	4.6	5.9
10. Astronomy	6.9	5.8	3.8	5.2	5.4
11. Forms of Energy, Applications	4.3	5.8	3.8	6.0	4.9
12. Conservation	3.3	4.8	5.9	2.6	4.2
13. Plant Life	4.0	3.0	4.4	3.6	3.8
14. Principles of Chemistry	2.9	3.1	3.3	4.8	3.4
15. Mechanics	2.4	2.0	1.7	2.5	2.1

It will be seen that about 20 per cent of the total newspaper space for science is devoted to Health and Medicine; this is more than twice as much volume as is devoted to the next highest major-topic. Furthermore, the proportion of space devoted to Health and Medicine remained practically constant during the four-year sampling of the ten-year interval covered in the newspaper study. Cancer is the disease receiving the greatest newspaper attention. Alcholism was a prominent feature in 1930, but showed a rapid decline following the repeal of prohibition in 1933. It is interesting to note that venereal disease received no mention at all until 1936, but has been increasingly featured in the newspapers since then.

The attention given to Communication and Transportation declined in 1933 from its 1930 level, thereafter remaining fairly constant. This sudden falling off in 1933 is explained to a large degree by the interest shown in the activities of several large dirigibles in 1930. Radio is the sub-topic receiving the greatest newspaper space under Communication and Transportation. It is interesting to note that the amount of technical material on radio decreased from 1930 to 1939, although approximately the same space was given to radio and broadcasting. Apparently as the radio industry became more stabilized, the technical phases no longer were given as much attention as they were earlier.

There was a slight, but definite, falling off in the space devoted to Animal Life, during the four years studied. The proportion devoted to this topic in 1939 was one-third less than in 1930. A similar gradual decline was shown in Man and Behavior and in Earth Science. The material under Animal Life dealt chiefly with descriptions of animals and their habits. Insects and their control was the most important sub-topic, followed by birds and migration.

The newspaper devoted an appreciable share of its attention to man, his psychology, and the bearing of science upon his living. This comprised the major-topic Man and His Behavior. Biography of scientists, and historical material were thought to belong more properly under this topic, rather than any other. Ethnology and archeology were, after much hesitation, omitted as being more likely to be included in the social science field. Anthropology was the most voluminous subtopic under this major-topic.

The topic, Gardening and Agriculture, increased in 1933 slightly over 1930. In 1936 it increased more than four-fold over 1933. The explanation for this was that a Sunday gardening section was begun in 1934. Since Sunday editions of large newspapers have a large sale in suburban and rural areas, this section was probably introduced for the benefit of the suburban and rural reading public. The Sunday Gardening and Agriculture Department was not a feature limited, however, to the New York Times. It was found also in the New York Herald Tribune, Chicago Tribune, Philadelphia Inquirer, and Philadelphia Record. Most of these papers had introduced the department before 1930. It seems reasonable to assume that Gardening and Agriculture is figured in Sunday papers of large circulation generally, and is not peculiar to the New York Times.

Attention to Earth Science showed a general decline between 1930 and 1939. The declining attention was especially noticeable with respect to earthquakes, paleontology, caves, and earth strata.

Weather and Forecasting included clouds, humidity, and fog as well as winds and storms.

Much of the chemistry material in the newspaper is in the applied field, and is usually presented with the assumption that the reader possesses a broad background of chemistry. After remaining fairly constant during 1930, 1933, and 1936, the importance of Applied Chemistry as meas-

ured by volume of space increased in 1939. Sub-topics which markedly increased were synthetic textiles, plastics, and photography. Considerable attention was given to the testing and preservation of food. Applied Chemistry will probably continue to grow in newspaper importance.

Grouped together under Atomic Investigation and Theoretical Physics were atoms and "atom smashers," cosmic rays, radium and radioactivity, X-rays, and theories such as relativity.

More space was devoted to Astronomy in 1930 than in any of the subsequent years. The explanation for this is the discovery of the new planet, Pluto, during that year. The distribution of space among the other sub-topics remained comparatively constant during the four years studied.

Since the space devoted individually to light, heat, sound, and electricity was comparatively small, these fields were all placed together under the major-topic Forms of Energy and Applications. In comparison to the attention given to sound in most general science textbooks, the space devoted to it in the newspaper is very small.

Conservation attained its greatest importance during 1936, a year of severe drought. There was marked newspaper interest then in dust storms, erosion, and their control. The whole topic of conservation fell off greatly in the newspapers during 1939.

Under Plant Life, the attention given to lower plant forms, excepting yeasts and mushrooms, was very small. Trees and wood products occupied a position of importance in this major-topic. Botany in the newspaper was chiefly concerned with gardening and agriculture, topics which have received separate treatment.

Under Principles of Chemistry, emphasis upon organic chemistry increased between 1930 and 1939. As indicated earlier, the chemistry in the news dealt more with applications than principles. The references to principles were usually brief, often assuming a basic knowledge of chemistry on the part of the reader.

The emphasis upon mechanics, while comparatively small, was fairly consistent throughout the years studied.

The fifteen major-topics were ranked in order of descending amounts of space for each year, and the rankings correlated.* The correlations are shown in Table III.

TABLE III

CORRELATIONS BETWEEN RANKINGS OF MAJOR-TOPICS IN THE NEW YORK TIMES BY YEARS

Years	*Index of Correlation*	*Probable Error*
1930–1933	+ .94	± .02
1930–1936	+ .48	± .14
1930–1939	+ .50	± .14
1933–1936	+ .57	± .12
1936–1939	+ .64	± .11
1933–1939	+ .52	± .13

The correlation between 1930 and 1933 is quite high, +.94. The chief cause of the low correlation of +.48 between 1930 and 1936 is the sudden elevation of Gardening and Agriculture from rank twelve in 1933, to rank two in 1936. The correlation between 1930 and 1936, omitting Gardening and Agriculture rises to +.68. The correlations between 1930–36, 1930–39, 1933–36, and 1933–39 are of small significance because of the large size of their probable errors.

Although the determination is not exact, it is possible to estimate the approximate proportion of space devoted to biological science, and the proportion devoted to physical science by combining the per cents shown in Table II. Health and Medicine,

* The formulas were:

$$\rho\ (\text{rho}) = 1 - \frac{\Sigma D^2}{n(n^2-1)}$$

$$\text{P.E.}_{\ r \text{ from } \rho} = \frac{.7063\,(1-r^2)}{\sqrt{n}}$$

Animal Life, Man and Behavior, Gardening and Agriculture, Conservation, and Plant Life, were combined under Biological Science, while the remaining nine major-topics were combined under Physical Science. The results are indicated in Table IV.

TABLE IV

PER CENT OF SPACE DEVOTED TO BIOLOGICAL SCIENCE AND PHYSICAL SCIENCE IN NEW YORK TIMES DURING YEARS 1930, 1933, 1936, 1939

	1930	*1933*	*1936*	*1939*	*Total*
Biological Science	47.2	49.0	57.8	47.1	50.5
Physical Science	52.8	51.0	42.2	52.9	49.5

During 1930, 1933, and 1939, the proportions are comparable, the physical sciences receiving slightly more attention than the biological sciences. In 1936, however, the biological sciences were appreciably greater than the physical sciences. The distribution in 1936 is probably to a large degree explained by the increased attention given to conservation because of the drought, and the introduction of the Gardening Section.

The average for the four years indicated that the space devoted to the biological sciences was almost equal to the space devoted to physical science.

SUMMARY OF FINDINGS

The major findings may be summarized as follows:

1. Of the fifteen major-topics in Science, Health and Medicine had most space devoted to it during each of the four years of the New York Times analyzed. This topic averaged 20.1 per cent, or about one-fifth of all the space devoted to science. This was well over twice as much space as was devoted to second ranking Communication and Transportation.

2. The correlations between the major-topic rankings in the New York Times are significant and vary as shown in Table III.

3. The per cent of space devoted to Applied Chemistry, and Gardening and Agriculture, showed progressive increase during the four years studied. The per cent of space devoted to Animal Life, Man and Behavior, and Earth Science showed progressive decrease. No definite trends were found for the remaining major-topics.

4. Approximately 50.5 per cent of the newspaper space was devoted to biological science, and 49.5 per cent was devoted to physical science.

RECOMMENDATIONS

As an outgrowth of this investigation, it seems desirable to make the following recommendations:

1. Similar analyses should be made of the science content of other newspapers, and of both general and popular science magazines.
2. The science appearing in radio programs and the motion pictures might well be analyzed with a view to determining its kind and accuracy.
3. The use of "Science" as an aid to advertising should be analyzed to determine the accuracy of the science appearing there, such as the study reported by Cox, McCollum, and Watkins,[4] but on a larger scale.
4. More comprehensive studies of the science vocabulary of newspapers should be made to supplement existing studies, most of which were made fifteen or more years ago.[5]
5. Instruction in science on all grade levels can be greatly enriched by the introduction of pertinent items in "current science", as they appear in newspapers.

It should be reiterated that the results of a newspaper analysis cannot be used as a sole basis for setting up courses of study. They are to be recommended, however, as one of the sources of relatively objective material. Combined with analyses of other periodical literature, the results cannot be ignored by curriculum specialists.

[4] Cox, Treffie, McCollum, J. S., and Watkins, Ralph K. "Science Claims in Magazine Advertising." *Science Education* 22:14–19, 85–87; January and February, 1938.

[5] See Curtis, Francis D. *Investigations of Vocabulary in Textbooks of Science for Secondary Schools.* (A compilation of most of the significant vocabulary studies in Science). Boston: Ginn and Company, 1938.

HUMAN ENGINEERING

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America today is more conscious than ever before of the square peg in the round hole. Men in high places, whose success or failure is blazoned on the pages of the daily press, give evidence that not all are in their right niches. In the majority of cases it is not to be denied that they are prominent, brilliant and capable men. It is likewise evident that not all are doing exactly what they are best fitted to do.

Similarly, if not in such a spectacular manner, many average Americans are groping for the work which they can do best. Given enough time, most will gravitate toward jobs for which they are best adapted. The inexorable "survival of the fittest" will drive some men involuntarily from one type of work to another, will show some that the channel which they are following was not meant for them. Given enough time, yes; yet time, under any circumstances, is precious. A man can little afford to waste the best years of his life shifting from one type of work to another in an attempt to find his place. Today time is paramount; it is imperative that everyone know just what he can do and do it as quickly as possible.

This year the Human Engineering Laboratory will evaluate the measurable aptitudes of upwards of eight thousand individuals. Some will be sent in by industrial organizations seeking further data on the potentialities of applicants and employees. About a third of the group will be adults who wish to learn more about themselves in order to apply their talents more effectively in the world of work. The majority will be boys and girls still in school who are looking ahead to what they ought to do after finishing their education, who are meanwhile trying to determine what to study and where their difficulties may lie.

The boy or girl in school today, trying to prepare for the occupational world ahead, faces an extremely complex problem and one that grows more complex with the passing of time. The ramifications of gainful employment are vast. Mass production, specialization, and big business, as well as the advancement of our frontiers of knowledge in every field have had no small part in creating these innumerable opportunities. Such factors, however, have added greater confusion to the problem of the adolescent trying to select his place in the world of work.

Test measurement alone will not solve these educational and vocational problems of which aptitudes are but a part. Each individual must consider a multitude of factors. Interests, likes and dislikes, opportunities, economic needs, and geographical location are a few of these other important elements to be weighed. What can be gained from test measurements? Let us look back over their development for an answer to this question.

The Human Engineering Laboratory started some twenty years ago to make up sample jobs of various kinds of work. Each was designed to sample some activity which entered a particular job. Each was admittedly made on the basis of hunch, as there were no set rules by which to be guided, no formula which would assure an accurate and significant sampling.

Sample jobs were designed to measure activities which seemed to be present in engineering, accounting, manual assembly work and administrative work, to name a

few of the jobs. Each sample was then subjected to rigorous check. Was the measurement obtained an accurate one? If not, the sample was modified, usually as a result of statistical study, to yield a more accurate measure. If and when the measure obtained was an accurate one, did it measure the desired activity in the job being analysed? In other words, did the sample job yield a measurement which separated the successful from the non-successful in the job in question? Would the measurement *predict* performance on a particular job if applicants for these jobs were tested first?

Not all of these samples worked. In many cases it was necessary to try thirty or forty different ones before successfully measuring some desired activity. For instance, let us trace briefly the development of the so-called engineering worksample A sample was made which it was felt would measure the desired activity. A group of men known to be successful in engineering were asked to try it. They failed, in that they did it no better than people in general. This sample was discarded and a new one constructed. Again a group of successful engineers were asked to try this, and again they did it no better than the general population. Some thirty of these samples were tried. In almost every instance it did not differentiate the successful engineer from the general group. It certainly did not mean that these men were poor engineers. They had, through practical experience, shown that they were good engineers. It meant simply that the sample had failed to measure the trait which the engineer possessed in greater degree than people in general, a trait which was important in engineering. Finally a sample was found which was not only an accurate measure of something but was one on which engineers excelled.

Two questions arose: Did the sample measure engineering training and experience, something which almost anyone could get by going to an engineering school or by working in an engineering office, or did it measure some basic ability of the engineer, an aptitude so to speak, which was essentially inherent in the individual and not the result of schooling or experience? Second, was the measure significant in predicting the future success or failure of boys who were planning on an engineering career?

A group of boys were measured and were then subsequently followed over a period of years. Scores on the sample job were divided into quartiles, and each group was followed closely. The majority (about seventy per cent) of those in the top quarter of the total group successfully completed engineering training and found their niches in some form of engineering work, whereas extremely few in the lowest quartile stayed in the engineering field. It did not mean that these boys were total failures. Some did find that engineering was not the type of work for which they were fitted. Others, however, found that their interests shifted, and that other lines of endeavor interested them more. The few who did score low and remained in engineering were followed carefully, yet to all intents and purposes these men were just as successful in engineering as the top men on the sample job.

This last finding is significant. It is evident to all that if a measure is to mean anything it must be obtained under standard conditions by a worker trained in obtaining accurate measurements. Equally important, and far more serious in its implication, is the interpretation given a measurement. The use and interpretation of tests is even more important than the measurement itself. For instance, scores obtained on the sample discussed previously do not indicate "You should be an engineer" or "You should not be an engineer." Remember that not all of the top quarter men succeeded nor did all of the lowest quarter men fail. It does indi-

cate relative chance of success or failure, a fact which can be used by industry to great advantage in hiring hundreds of workers for a particular job. They are interested in the highest possible percentage of successful workers. By hiring men who score in the top quarter in the aptitude which is significant for the job in question they would acquire a group which would include relatively few unsuccessful workers. At the same time, by not hiring those who scored low, they would lose a few who would have been successful; but the majority thus rejected would not have proved satisfactory.

This is not true of the individual. He is not made up of a hundred entities, some of which will succeed, some of which will fail. He stands to achieve some measure of success or to be a failure; he cannot be both. Such a measurement must be used cautiously in individual guidance. Many other factors affecting success or failure on a job must be weighed carefully before any definite conclusion is reached regarding occupational selection.

Returning to the sample job of engineering, since it had worked well in the engineering job, this question arose: Would this same sample measure a significant activity in some other type of work? It was worth trying. Further research showed that scientists were high, that tool and die-makers, draftsmen and mechanics were high. Indeed, tool and die-makers appeared to score higher on the sample than the engineering group previously measured. Yet, all in all, it was not particularly surprising that these other groups of workers scored high. All of these jobs have a good deal in common. Basically, they are similar to engineering. The real surprise came when surgeons were measured. They not only were high on the sample, but proved to be significantly higher than any of the other groups previously measured.

All of these facts serve to indicate that the original sample job is not simply an indication of performance in one particular type of work, but a worksample which measures some faculty in man's physical or mental makeup, and which shows considerable variation among individuals. It appears to be essentially independent of training or experience. The Laboratory has designated such a measure an aptitude.

What activity is being measured by the worksample which has been discussed in some detail in the preceding paragraphs? Or, to put it another way, what activity is common to engineering, science, tool and die-making, surgery, and drafting that is being measured by the sample job? What aptitude is being measured?

Careful consideration of the facts has led the Laboratory to the conclusion that some spatial sense is being measured, an ability to visualize structure, to "see" three dimensions. Consider each job listed with which this aptitude checks. Each is primarily a field dealing with solid form, with some type of structure. The engineer is concerned with machinery, bridges, other types of structures. The tool and die-makers and the draftsmen are concerned with similar things. The scientist must visualize easily the structure of atoms, the surgeon the complex structure of the human body. To assign a name to this aptitude, the Laboratory has called it *Structural Visualization.*

Further studies brought out several interesting findings. If the median score for each age is plotted, the graph obtained is similar to the age height curve. For males, the median score rises with age to about the age of nineteen, then flattens out for some twenty years, after which the curve falls off slightly. For females, the point of maturation appears some three or four years earlier, although the general shape of the curve appears to be the same. There is, however, a large sex difference. Women in general are noticeably lower than men. Norms for the worksample

show that less than five per cent of the women score as high as the top twenty-five per cent of men.

This last finding checks with the actual distribution of men and women in "structural" jobs. Granted that custom and other factors contribute greatly to the overwhelming preponderance of men in these fields, it still appears on the basis of measurement that men are far more suited to this type of work. Yet, it cannot be overemphasized that a woman who is very high in Structural Visualization should strive to use this aptitude which on the whole is not predominant for her sex. Particularly in the present world crisis, with more and more men being called into the armed forces, women are needed in industry and needed badly. The need is particularly urgent for women who are high in Structural Visualization and who in addition possess the necessary academic and practical experience. Far too many women, unaware of the structural ability which they possess, have pursued training which does not fit them in the least to make effective use of the aptitude. The aptitude alone, it goes without saying, is useless; training and experience must be acquired to use it effectively.

Equally important is the lack of the aptitude, Structural Visualization. Bankers, accountants, salesmen and teachers average significantly low. It would appear that the possession of Structural Visualization in these more "intangible" fields serves as a handicap rather than as a help.

To date, the Laboratory has found measures for thirteen different aptitudes. They overlap but slightly, and would appear to be essentially separate entities, although more refinement through research study is needed to isolate completely each from the other. Space does not permit more than a listing of the names and the briefest description of them. The names assigned have been chosen to provide a convenient terminology with which to discuss them more easily; in certain instances the name may appear misleading and do more harm than good, but to date these have been the best which have been devised by the staff. The aptitudes follow:

1. Structural Visualization—already discussed in detail previously. This is a facility in visualizing solid form. High scores characterize engineers, architects, surgeons, tool and die-makers. Low scores characterize bankers, teachers, accountants and salesmen.

2. Accounting Aptitude—a facility in the rapid and accurate handling of figures and symbols, or pencil and paper detail. Accountants, bankers, auditors, secretaries, and to a lesser degree, teachers and executives, are high.

3. Personality—a measure of the difference between the group worker (called objective) and the individual worker (called subjective). Salesmen and teachers tend to be objective, research workers and surgeons, for example, subjective.

4. Finger Dexterity—one type of manual dexterity. File clerks, violinists, bank tellers, those doing various manual assembly jobs using their fingers rate high. Finger Dexterity is basically an aptitude rather than a skill as it might appear.

5. Tweezer Dexterity—facility with small tools. This is independent of finger dexterity. Surgeons and miniature instrument assemblers, to name two groups, score high.

6. Creative Imagination—probably more accurately described as fluency of ideas. Scores check well with patents issued in engineering work, and writers, teachers, and salesmen rate high.

7. Inductive Reasoning—difficult to measure accurately. It appears to be a facility in finding the common factor or factors in apparently unrelated entities. Research scientists seeking general laws from isolated experiments appear to be high. Indications are also that writers and teachers are outstanding.

8. Observation—factory inspectors are the highest group yet measured. This is a facility in spotting variations from some standard.

9. Tonal Memory—facility in carrying a tune. Professional musicians rate high although there are indications that certain groups of workers other than musicians may also be high.

10. Analytical Reasoning—the measure for this is not yet entirely independent of inductive reasoning, but the relationship appears low enough to indicate a different aptitude. Analytical Reasoning appears to be a facility in the logical arranging of ideas or facts. Little validation is available as yet, but editors are one group who rank significantly high.

11. Number Memory—one type of memory. This is independent of tonal memory discussed previously. Stock room workers, production followers or expeditors score high, and there is also some indication that stock traders are high.

12. Memory for Design—an aptitude although its actual identification is still vague. One indication is that it plays a part in sketching.

13. Muscular Speed—accurately measurable although significance not yet ascertained statistically. This may give some indication of physical or mental endurance, or may show why some are capable of more sustained activity than others.

This list is naturally incomplete. Many more aptitudes undoubtedly exist, and research is going on apace to find the means of measuring and identifying others. At the present writing, numerous experimental worksamples are going through the mill. Most will ultimately be cast aside as of little or no value, but a few will eventually serve as a means of evaluating other characteristics in the mental and physical makeup of man.

The Human Engineering Laboratory, under the sponsorship of Stevens Institute of Technology, Hoboken, New Jersey, maintains laboratories in Hoboken, at 347 Beacon Street, Boston, Massachusetts, and at Chestnut Hill Academy in the environs of Philadelphia. A fourth laboratory, under the sponsorship of Illinois Institute of Technology, is located in Chicago. Each laboratory offers any individual over the age of eight an opportunity to try worksamples which measure these different aptitudes and in turn try some of the experimental worksamples to help advance the frontiers of this whole field of mental measurement. Although considerable money and material for the carrying on of the research is made available by numerous individuals and philanthropic and business organizations, it is necessary for the maintenance of such a service to charge each individual a fee. This varies from ten to thirty dollars, depending on age or grade in school, and the completeness of the examination desired. A single appointment of three hours allows for the measurement of four or five aptitudes; a double appointment, two sessions of three hours each, is necessary to measure the majority of these aptitudes.

In all of its research thus far, the Laboratory has found no job which calls on the use of all of these aptitudes. In general, most jobs appear to tax the use of but a few. Yet, in terms of these thirteen characteristics, ninety-one per cent of the population measured possess somewhere between four and nine of these aptitudes. A knowledge of the aptitudes of the individual does enable the Laboratory to point out that person's strengths and weaknesses, and the individual, fortified with this additional knowledge, can plot his course in his educational and occupational life more intelligently. He has the opportunity to see better his present potentialities, and these will serve to help him to reach out and strive to use more of them. Ability must be challenged. Too many people today are restless and dissatisfied, not because they are necessarily in the wrong job, but mainly because they have not used effectively every aptitude which they possess.

America faces a job, unpleasant though it may be, that must be done. Buying bonds helps greatly to finance this tremendous effort, but that alone will not see us through the conflict and the long period of readjustment which will follow. America, and that means all of us, must rise above itself. Each of us must strive to do the best that is in him. It means using every potentiality which one has. A better understanding of strengths and weaknesses, revealed through a scientific sampling of aptitudes, should help clarify the issue for each individual, and enable him to do his utmost to ultilize most effectively that which he has. Not only will he be doing his fullest share at present and in the years to come, but in so doing, each should be happier and more successful in living a fuller life.

THE NATIONAL COMMITTEE ON SCIENCE TEACHING *

IRA C. DAVIS
University of Wisconsin

The greatest impetus for the organization of a representative committee of science teachers came from the Educational Policies Commission. Their report on "The Purposes of Education in American Democracy" raised challenging issues which all subject matter areas should consider. What can science education contribute toward helping pupils to better understand democracy? How can it help boys and girls to live in this democracy? How can science help to give boys and girls a better living? How can science assist in solving the social problems it has helped to create?

The main purpose in organizing the committee was to secure a representative group of science teachers to interpret and implement the recommendations made in the reports of the Educational Policies Commission. As the work of the Committee progressed, it was found that the recent reports of other educational organizations and agencies would be helpful.

The initiative for the organization is probably due to the efforts of the officers of the Department of Science Instruction of the National Education Association, although it is difficult to tell where any such movement really begins. The Department was successful in getting funds from the National Education Association to help organize and support the activities of the Committee. Nine other national organizations of science teachers accepted the invitation to cooperate, and they also have contributed financially, as well as in many other ways. Two other national organizations sent delegates to participate in some of the meetings.

* Presented at the February, 1942, meeting of the National Association for Research in Science Teaching.

The first, or organization, meeting was held in Cleveland in February, 1939. Thirty-five representatives attended this meeting. Records demonstrated that the teachers present were in direct contact as administrators, supervisors, or heads of departments with more than 5,000 science teachers. Attendance at later meetings varied from 60 to 100 teachers. In a check-up at two meetings, it was found that the teachers present represented more than 11,000 teachers. I mention these figures to point out the fact that the Committee was really interested in getting a large number of teachers to cooperate and assist in the work. Every effort within the limits of time and funds has been made to acquaint large numbers with the work and progress of the Committee.

The Committee practiced democracy as it understood democracy. At no time has the Committee taken the position it should write a report or reports that would represent its own opinions without first considering the suggestions and recommendations of thousands of teachers. It at no time has had any desire to dictate a program. Rather, its function has been to study, to interpret and re-interpret, to consider and re-consider, to plan and re-plan, and finally produce reports which would represent the thinking and actions of many teachers.

The Committee members have, in spirit at least, attempted to be scientific and at the same time democratic.

The Committee has held nine meetings in all. Three were joint meetings with other groups. The general committee consists of 17 members elected by the co-operating organizations. More than 265 other teachers, called consultants, have

made valuable contributions. They come from all parts of the United States, and represent all types of schools, as well as all school levels.

More than 2,200 teachers answered the opinionaire and questionnaire distributed by the Research Division of the N.E.A., and which was prepared by the Sub-Committee on Teacher Education. An additional 3,000 teachers assisted in the work of the Sub-Committee on Needs.

It soon became evident that it would be desirable to divide the general committee and consultants into several smaller groups to make it possible for the large number who attended the meetings to take part in discussions. As a result, seven sub-committees were formed—namely, (1) philosophy, (2) needs, (3) teacher education, (4) evaluation, (5) effective procedures, (6) effective materials, and (7) administration. Members of the general committee were elected chairmen of the sub-committees. Other members of the committee and the large number of consultants were assigned to the sub-committees which they preferred. In order to keep all sub-committees working together and in some agreement with each other, it was decided that they should meet together several times during the two or three-day meetings and still more times in sub-committee groups.

In this way it was possible to make the best use of all available talent and keep the work progressing in a more or less sequential order.

I hope you do not think there was unanimous agreement of opinion or that all members of the Committee always agreed on everything that was proposed and accepted. There were many differences of opinion. Sometimes they were more or less violent. But not once do I recall that the differences were personal or that anyone attempted to force others to accept his or her opinion or point of view. Every proposal and every action had to run the gauntlet of opinion of all members, and many times of all the consultants.

Oftentimes, there were misunderstandings, but as far as I know never a questioning of motives. Sometimes slight jealousies were apparent, but they soon disappeared as the discussions progressed and understandings became more complete.

I am certain that the members of the Committee do not want me to give the impression they were all saints, or could do no wrong, or never made any mistakes. Personally, I am convinced now, more than ever, there is something to scientific training and thinking which makes it possible for such a large and capable group to work together so harmoniously and so effectively—yes, too, democratically.

You are no doubt raising this question by this time: Could such a large group ever come to an agreement on anything?

I am glad to report that three sub-committees have completed their work. Their final reports are now ready for the printer. The three reports completed are: *Science Teaching for Better Living—A Philosophy or Point of View, Re-directing Science Teaching in the Light of Social-Personal Needs,* and *The Education of the Science Teacher.** A fourth report on effective teaching procedures and materials is expected to be completed by summer or fall. It will contain the reports of the sub-committees on materials and procedures and possibly some recommendations of an administrative nature.

At some time in the future it will be necessary to evaluate the suggested program. There will be time then for a complete report on possible ways and measures for evaluating what teachers have attempted to do.

I am sure you do not want me to tell

* *Editor's Note.*—Since this manuscript was received, these three very excellent reports have been published by the American Council of Science Teachers of the National Education Association, 1201 Sixteenth Street, Washington, D. C.

you what is in the reports. As chairman I should be the last one to "beat the gun" and tell you what they contain before they are published. At no time has there been any attempt to be secretive. I can give you a hint of what is in them by telling you what is *not* in them.

First of all, you should not forget that the members of the Committee and practically all of the consultants are science teachers. Certainly none of them are the least bit interested in doing anything that would bring injury or harm to science teaching. They are interested in more science teaching—not less. Their main and consuming interest has been the improvement and expansion of science teaching. They may find later that the recommendations made in the reports will not improve science teaching, and, if such is the case, then the members can say they misinterpreted the reactions, opinions, and suggestions of thousands of teachers. The mistake was theirs, not the teachers!

All of the reports are published under the signatures of all members of the Committee. There are no minority or dissenting reports. However, the Committee members hope there will be many dissenting opinions when the reports are read and teachers have had an opportunity to react. Please do not assume that all members of the Committee agree with all parts of the reports. In saying they agreed to sign them, the members believed the reports were good enough to be published and good enough to deserve the consideration of science teachers. They do not expect unanimous agreement. That would be dangerous.

The Committee reports do not contain any specifics for courses of study, methods of teaching, or modes of organization. The Committee members knew many teachers wanted them to furnish the specifics for everything. They heard constantly—"Give us something that will work in the classroom."

The report on Procedures and Materials will give illustrations of how some teachers do the things the Committee is suggesting. These illustrations will help to give meaning to the recommendations and are not intended to be specifics. They will be suggestive, not prescriptive.

The Committee has attempted to bring its reports up to the point where others will produce materials to be used in the classroom. This will mean the new and more purposeful content that is needed in many areas, new or revised textbooks, new points of view with some changes in methods of teaching and a place to teach science which is as broad as the community itself.

Teachers will, no doubt, be surprised to learn that the reports say very little about what we are doing in science at the present time. They neither condemn nor approve what is being done now, with the possible exception of the one criticism—"Our science teaching has not been as functional as it might have been."

You will all agree with that criticism, I am sure. The reports do not recommend that the present courses of study or subject matter be discarded; they do not suggest new courses, neither do they condemn the core curriculum, new organization of content, an entirely new selection of content, easy courses, or anything new that is being offered.

And, further, the reports do not mention or condemn any other subject matter areas. You will wonder why specific recommendations are not included. The answer is easy—the Committee refuses to tell you what the best method is for teaching science on a functional basis when it does not know what it *is*. It would be unscientific if it said it did.

However, the Committee has, I think, some very sound and practical suggestions for the functional teaching of science. The report on *Science Teaching for Better Living* gives the Committee's point of view

on functional teaching and the areas in which the outcomes of functional teaching can best be derived. The report on *Redirecting Science Teaching in the Light of Social-Personal Needs* lists many specific needs or outcomes in the areas suggested in the first report. The report on *The Education of the Science Teacher* suggests a program for educating the new science teacher to meet the additional areas of preparation which the future will demand.

Approximately 85 per cent of science teachers do not teach controversial issues largely created by science. Their main reason is, they say—"We were not prepared to do it." Approximately the same number say—"Pupils would be better off if these issues were taught in class than they are by using the material which is taught now." The teachers are not doing what they think should be done because they were not trained or educated to do it.

One illustration will help to make clear what I have said about the reports. We teach some facts and principles about water in all of our science classes. We make some application and talk about water systems, water pressure, hydraulic appliances, and how bacteria are spread by water. So far, so good. This is necessary. This is what we have been doing. There is no criticism of this at all.

But, let us ask ourselves this question: How has what we have taught affected or changed the thinking, the action, and the behavior of the boys and girls who are doing the learning? Will they, because of what they have learned, drink more water, always insist on drinking pure water, clean up mud holes and mosquito breeding places in their communities, keep themselves and their clothing clean, take part in activities which will protect the purity of the community's water supply, refrain from swimming in the water reservoir, repair a faucet if it leaks, vote intelligently on measures involving the conservation of our water resources, not go into deep water until they have learned to swim, and many other activities which may be mentioned?

When we can get boys and girls to act and do things, and make it a part of their everyday living because of what they learn in science, then science teaching will have become functional. Here is where the Committee begins to make recommendations. How can we go on from what we have been doing, or where we are, to where we ought to be—that is, make science a vital, living, and necessary part of the everyday life of each boy and girl, as well as the community in which they live?

Can science be taught in a functional way by beginning with subject matter as we have been doing, or must we begin with specific outcomes and then select the subject matter best suited to teach these outcomes? The Committee does not attempt to answer the question. It hopes both procedures will be used. Certainly, open-minded science teachers will not throw up their hands in horror if some persons attempt to teach science by using desirable outcomes as the beginning point.

Will the Committee's reports help to implement and translate into classroom practice the challenging issues raised in the reports of the Educational Policies Commission? The Committee believes they will. And, still further, the Committee hopes its reports will help to give science a more prominent and rightful place in the curriculums of the schools in the future. You may rest assured the Committee hopes its reports will give science a much more prominent place than do the reports of the Educational Policies Commission.

HARRY A. CARPENTER

Born February 7, 1878; Died April 5, 1942

The last time Harry Carpenter met with a national group of science teachers he told us of having had his sixty-fourth birthday, that he would soon retire, and so many things to do were facing him that his retirement would really mean added opportunity. More than twenty-five years earlier I had learned of Carpenter's unusual qualities as a classroom teacher. His clear, kindly, forceful, and direct thinking so readily noted by his students, also caused him to be sought constantly for many services outside classrooms. He was widely and favorably known wherever science for young people was considered. For him science was a means of doing useful things for young people. His vision of educational goals was clear. His efforts toward his goals were not wobbly but guided by carefully studied experience. His ambitions were unselfish, though he keenly and properly appreciated approval from those whom he trusted and respected. His enduring monument consists of his splendid character and his achievements as they reappear in the lives of those who knew him.

We shall indicate some parts of Carpenter's work, knowing well, however, that such a man is far more than the sum of the parts. After a few years of important teaching experience in smaller high schools, he began his almost four decades of teaching in Rochester high schools. He was head of the Chemistry Department of the West High School. Later his teaching dealt also with physics. He made important revisions in the courses in chemistry and physics. When junior high schools began to develop, Carpenter developed appropriate courses in science. These were published as textbooks which were widely used. During recent years he was supervisor or "specialist in science" for all the Rochester high schools. The Rochester Board of Education early sensed the meaning of the kind of science which functions, and allowed Carpenter to make analytical tests of paints, varnishes, roofing materials, soaps, etc. This resulted in laboratory-determined technical specifications upon which the Board's purchases were made. The devices for keeping the water of swimming pools in healthful condition were installed and managed under guidance of this science teacher. New types of science courses for pupils of all ages were devised and developed through experimental use.

When radio became common, Carpenter began experiments in teaching by use of radio. His first broadcasts were for pupils of junior high school ages, and were local. But parents and older and younger pupils over a wide geographic range listened and reported. Thus this radio experiment grew into one of the most successful and most widely appreciated radio broadcasts. Many of the radio lessons on science were recorded in permanent form, thus made available for later uses.

Interest in the professional welfare of science teachers was almost a hobby for Carpenter. Local, state, and national groups of teachers enlisted his interest. He was a wise leader in moves for improvement of science teaching by giving help to teachers. To him more than to any other is due credit for organizing and guiding the American Science Teachers Association through its first ten years. That organization as well as others to which he belonged will learn to appreciate, even

Editor's Note.—This statement concerning our good friend and associate editor was prepared at our request by Otis W. Caldwell. But for our change in publication plans it would have appeared earlier.

more than they now do, how much they owe to this one great leader in science education.

There is an unnamed fraternity of purposeful teachers. It has no time-set initiation, no final pledges, no bond of secrecy, no exclusive agreements or practices, and no program to which it asks unanimous approval. Membership in this fraternity is established by each individual's character, quality of human service, unselfish devotion to the highest good for those who are served through the ministrations of education. Carpenter was a high ranking member of that fraternity.

A list of Carpenter's activities and his publications about science teaching is appended. This was prepared by the loyal secretary who was an essential part of his many enterprises.

BIOGRAPHICAL NOTES CONCERNING MR. CARPENTER

Born February 7, 1878, Honeoye Falls, N. Y.
Died, April 5, 1942, Rochester, N. Y.

1902 Graduated from the University of Rochester, B.S. Degree.

1902–4 Science teacher Albion High School, Albion, N. Y.

1904–5 Science teacher Johnstown, N. Y.

1905 Head of Chemistry Department, West High School, Rochester, N. Y. Later Biology Department was added.

1909 Testing Laboratory.

At the request of the Board of Education Mr. Carpenter developed a testing laboratory for various materials purchased by the Board. In this laboratory, under his direction, are written technical specifications for paints, varnishes, roofing asphalts, felts, soaps, milk, chocolate milk, and various other types of materials. The purchase of supplies is made on the basis of analytical results.

A part of the work in this department consists in sampling and testing the water of the various swimming pools in the city. As a result of this work there has accumulated a most valuable set of data relating to the operation of pools, sterilized by the use of chlorine, chlorine-ammonia, and ultra-violet ray.

1910 The physics work of the school, which to this time had been almost exclusively theoretical, mathematical, and college preparatory, was differentiated better to meet the needs of different types of pupils. The new work for girls was organized and directed by Mr. Carpenter.

1912 Granted the M.S. degree by the University of Rochester for work in chemistry and pedagogy.

1912–3 Granted leave of absence by the Board of Education of Rochester to continue studies at Columbia University.

1913 Granted M.A. degree in chemistry and education by Columbia University.

1914 Assigned responsibility for developing a course in general science for Rochester's first junior high school, which opened in September 1915.

1917 In December of this year Mr. Carpenter was called to Washington, D. C., for war work as special assistant to the Chief Chemist of the Bureau of Mines, and served until February 1919.

1925 Appointed Specialist in Science for the Rochester Public Schools, which position he retained to the end.

1925 Appointed a member of the New York State General Science Syllabus Committee by the Commissioner of Education.

1926—to date—Lecturer in Education at University of Rochester.

1930 Traveled in Bermuda.

1931 Granted leave of absence for six months for travel and study of schools of the United States from coast to coast. Also traveled to Alaska and Yukon Territory.

1933 On February 7, Mr. Carpenter gave the first science program of the Rochester School of the Air, and continued broadcasting work in science until June 1941 when it was turned over to someone else. The science broadcasts are still being given. A unique feature of the radio science work is that it follows the official curriculum of the public schools. Pupils receiving radio instruction in science take the same examinations provided for those pupils housed in the high schools where science trained teachers and adequate science equipment are available. As a result of the demonstrated success of this work the first two years, radio instruction increased rapidly in Rochester and surrounding territory. Today science broadcasts reach 5th, 6th, 7th, and 8th grade pupils not only in about fifty Rochester schools, but also in some two hundred schools outside Rochester. Twenty and twenty-five thousand children are registered each semester.

1934 (Summer) Traveled in Europe.

1937 (Summer) Attended the conference of the World Federation of Education Associations in Tokyo, Japan, August 2 to 7, as Assistant General Secretary of the American Association for the Advance-

ment of Science. At this meeting was elected Secretary of the Science Section of the World Federation of Education Associations.

Traveled in the Hawaiian Islands, Philippine Islands, China, and Japan.

1939 January 21 to June. Conducted experiment with recorded science lessons for the Committee on Scientific Aids to Learning. Forty science lessons were recorded. The scripts were planned for ten-minute lessons, which were then followed up by teacher conducted class discussions. Weekly bulletins were mailed to the teachers. 171 teachers in 136 cities and 14 states participated in this experiment. There were 293 classes with an enrollment of approximately 10,000 pupils.

1939 (Summer) Traveled around South America and attended the meetings of the World Federation of Education Associations aboard the SS. Rotterdam. Served as Secretary of the Science Section of the W.F.E.A.

1939 Organized the Rochester Science Center for Rochester and surrounding counties. This center sponsors the scientific endeavors of pupils through club meetings and special interest groups.

1941 February 6. Fellowship Award of the American Institute of New York City.

Mr. Carpenter has been responsible for planning the laboratory arrangements and furniture for all of the junior-senior high schools built in the city since 1905.

Mr. Carpenter was associated with many educational associations, including the New York State Science Teachers Association of which he was president four different times. He was a member of the National Education Association and the American Association of School Administrators. He was one of the organizers and charter member of the Rochester Section of the American Chemical Society, having served as its president and national councilor. He was one of the organizers and a charter member of the National Association for Research in Science Teaching, served as a member of its executive committee, and was president during 1940. He was a charter member of the American Science Teachers Association, and president from its beginning in 1933 until 1939.

Because of his interest in visual education, Mr. Carpenter cooperated with the Eastman Kodak Company in the development of the first ten science teaching films which were used as a countrywide experiment, and was called in as consultant since that time.

He was a contributing editor for *Science Education* and *Journal of Chemical Education*. For some years he was the Elementary Science Editor of *School Science and Mathematics*.

PUBLICATIONS

Articles

1. "Ionization Theory." *School Science and Mathematics,* September and October 1909.
2. "General Science." The *Journal of New York State Teachers Association,* November 1916.
3. "General Science in Rochester, Part I." *General Science Quarterly,* November 1916.
4. "General Science in Rochester, Part II." *General Science Quarterly,* November 1917.
5. *New York State Syllabus in General Science.* University of the State of New York, Albany, 1925. (Member of Committee)
6. "Why Teach Chemistry in a New York State High School." *New York State Education,* February 1929.
7. "Fifteen Years of Experience in Developing a Science Course of Study for the Junior High School." *Junior-Senior Clearing House,* April 1930.
8. "Success in Physics and Chemistry in Relation to General Science and Biology." *Science Education,* May 1930.
9. "Science in the Elementary School." *School Science and Mathematics,* June 1930.
10. "Results of a Three-Year Science Sequence in the Junior High School Grades." *Science Education,* October 1933.
11. "Teaching Science by Radio." *Junior-Senior High School Clearing House,* March 1934.
12. "Science in the Junior High Schools of Rochester, New York." *Proceedings of the Department of Science Instruction of the National Education Association,* 1935.
13. "Class Programs: Seventh Grade Science." *Education on the Air,* 1936, The Ohio State University.
14. "Science in the Rochester School of the Air." *Science Education,* April 1937.
15. "Teaching Science by Radio." *The School Executive,* January 1938.
16. "Using the Radio for In-Service Training of Science Teachers." *Science Education,* November 1939.
17. "An Experiment with Recorded Science Lessons." *Science Education,* April 1940.
18. "Youth Speaks for Science." *Science Leaflet,* Volume XIV, No. 21, February 27, 1941.
19. "How Shall We Plan Rooms for the Different Activities in the Community High Schools?" Published in "Minutes of the Advisory Council of Education," Office of Education, Washington, D. C.
20. "What Lies Ahead in the Scientific Field." *Secondary Education,* April 19, 1941.
21. "Science, a Character Building Factor." *Rochester Commerce,* May 5, 1941.
22. Science in the Rochester School of the Air. *Current Science.*
23. "Scientific Gadgets Come to the Aid of Learning." *Education,* January, 1942.

Textbooks

1. Co-author of Book I, *Our Environment, Its Relation to Us,* Revised 1942.
2. Co-author of Book II, *Our Environments, How We Adapt Ourselves To It,* Revised 1937.
3. Co-author of Book III, *Our Environment, How We Use and Control It,* Revised 1940.
4. Co-author of Book IV, *Our Environment, The Living Things In It,* 1938.
5. Co-author of *Science Discovery Book I.*
6. Co-author of *Science Discovery Book II.*
7. Co-author of *Science Discovery Book III.*
8. Co-author of *Science Discovery Book IV.*
9. Co-author of Teachers' Manuals to accompany all books.
10. Co-author of Modern Tests to accompany all books.
11. Co-author of *Adventures in Science with Judy and Joe* (1st grade).
12. Co-author of *Adventures in Science with Bob and Don* (2nd grade).
13. Co-author of *Adventures in Science with Jane and Paul* (3rd grade).
14. Co-author of *Adventures in Science with Doris and Bill* (4th grade).

MEETING OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

The National Association for Research In Science Teaching held its fifteenth annual meeting at Hotel Allerton, Cleveland, Ohio, February 15, 16, and 17, 1942. The convention was inaugurated by the regular dinner meeting for members on Sunday evening. There were thirty members present.

Following the dinner the president, Mr. G. P. Cahoon of Ohio State University, addressed the membership on the subject "Competency Not Credit Hours." The meeting then turned to the consideration of routine business which consisted of reports by the Secretary-Treasurer, the Program Committee, the Association representative to the Dallas meeting of the American Science Teachers Association, the Association representative to the Conference for Cooperation in School Health Education, the Association representative on Science Education, and the Committee to study the problems of affiliation with other organizations of Science Teachers. The secretary read a paper summarizing the highlights of programs and business over the past fifteen years. The meeting was adjourned at 10:30 P.M.

The Monday morning session was opened with a short business meeting followed by four interesting papers.

1. Review of Significant Studies in Science Teaching, that have been reported during the Past Two Years by Nathan A. Neal.
2. Science Instruction in Schools of the Southern Association Study by Eugene A. Walters.
3. Science Implications of the Eight Year Study of the Progressive Education Association and of the Cooperative Study in General Education by Louis M. Heil.
4. Report of the Science Committee, Department of Science Instruction, National Education Association by Ira Davis.

The meeting was adjourned and a luncheon meeting for the Executive Committee was held.

The Monday afternoon meeting was devoted to two topics as follows:

1. What is Science? Mathew Leukiesh.
2. Science is Applied to Industry. O. F. Carpenter.

A dinner meeting was held in collaboration with the science teachers of Cleveland. Mr. Ellis C. Persing, Chairman of the Committee on Local Arrangements, presided. The following program was presented and greatly enjoyed.

1. Address of Welcome by Charles H. Lake, Superintendent of Schools.
2. The Cleveland Science Curriculum by James C. Adell, Arthur O. Baker, Nathan A. Neal.
3. Science in the Elementary School by Mary Melrose.
4. Spider Silk—Preparation and Use by Dr. John G. Albright.

On Tuesday morning the Association members were afforded a very unusual opportunity to hear Dr. George Crile and Dr. Quirling of the Cleveland Clinic discuss their researches and findings relating to Organs in Human Beings and other animals that affect Intelligence, Power and Personality. As the meeting was held at the Clinic, through the courtesy of Dr. Crile, the facilities of their very extensive museum were available to the members attending.

The afternoon of Tuesday was devoted to a series of trips to school buildings in Cleveland to observe modern lighting installations. These visits were under the direction of Mr. L. S. Ickis of the General Electric Company.

NOTICE

Because of emergency conditions the Conference on the Education of Science Teachers, Dr. Anna M. Gemmill, President, has cancelled the meeting which was to have been held in Boston in November and instead arranged a program for December the 28th at Teachers' College, Columbia University.

TO OUR SUBSCRIBERS

General Science Quarterly began publication twenty-six years ago under the editorship of Walter G. Whitman. In May, 1929, with the last issue of Volume 13, the name of the journal was changed to SCIENCE EDUCATION which was published for a little more than a year by an editorial committee representing the National Association for Research in Science Teaching. In 1931, the ownership of the journal was transferred to Science Education, Incorporated. This organization, through its editorial committee, has published the magazine since October, 1931.

The journal has served as the official organ of the National Association for Research in Science Teaching since that time, as the organ of the National Council on Elementary Science since April, 1932, and as the official publication of the Science Association of Middle States from November, 1932.

Published on a quarterly basis for twenty years, we grew to five issues in 1937 (Volume 21) and then to seven issues during the years 1938–1941 (Volumes 22 to 25). Throughout the period of publication, we have attempted to serve science teachers on a voluntary, non-profit basis. Those individuals who have given of their time and energy have done so without compensation. All of our receipts have gone into the best periodical we could publish on our spare time. When it became possible to increase the number of issues, as indicated above, we did so. With Volume 21 we found it necessary to advance the subscription rate because of increases in costs of materials and printing. Since that time, even though we have expanded to seven issues per volume, the subscription price has remained the same.

With some misgivings regarding our hopes and desires, we planned to publish seven issues of Volume 26 this year. Now for the first time in the history of the journal we are faced with the necessity of temporary curtailment of our plans. Four factors have prevented us from realizing our hopes. First, the number and quality of manuscripts submitted in these otherwise busy times have diminished. Second, there has been an increase in cost of materials and printing. Third, a decrease in our subscription list has resulted due to the demands of the armed services on our science teachers. And fourth, advertisements are more difficult to obtain in this critical period.

Accordingly we found it necessary to suspend publication of our March and April issues. The October and November issues appear herewith as a combined number. The December issue will appear about January first and will be a special issue on Elementary Science prepared in part by the National Council on Elementary Science. This temporary change in our publication plan is not of our own choice.

Subscriptions entered before December first will be adjusted by our business manager through proper extension of the subscription period.

The first issue of Volume 27 will appear under February, 1943, date. It is now planned to publish five issues during 1943 at the regular subscription price established in 1937.

As soon as conditions warrant, we shall resume our seven-issue schedule. In the meantime, your editorial committee will make every effort to improve the magazine and requests subscribers to submit materials for publication.

Finally, we have great confidence in the values of the contributions to science teaching made by the journal during the last twenty-six years. We are steadfast in our belief that, when these troublesome times shall have come to their inevitable and happy end, this journal which was first in its sole purpose to promote all science teaching at every school level will further prove its worth, integrity, and indispensability as an open forum for the improvement of science teaching in a democratic society.

Abstracts

GENERAL EDUCATION

Bagley, William C. "The Case for Essentialism in Education." *The Journal of the National Education Association* 30:201–202; October, 1941.

Two schools of educational theory have been in conflict for a long time. Here Bagley presents the case for Essentialism. In the November issue Kilpatrick will present the case for Progressivism.

The conflict may be indicated by pairing such opposites as: effort *versus* interest; discipline *versus* freedom; race experience *versus* individual experience; teacher-initiative *versus* learner-initiative; logical organization *versus* psychological organization; subjects *versus* activities; remote goals *versus* immediate goals; and the like. —C.M.P.

Kilpatrick, William H. "The Philosophy of the New Education." *School and Society* 54: 481–484; November 29, 1941.

Common general principles of the new education can be stated as: (1) "Respect for the human personality as such is accepted as the chief foundation stone for the new education. This includes all humans and, as far as humanly possible to effect it, on terms of equality." (2) "Society must conduct itself on the ethically equal treatment of all. All are to be treated, in Kant's phrase, always as ends and never as means merely. Nor is any stage of life, as childhood, to be treated as means merely to any later stage." (3) "The good life, or the life good to live, is the foundation conception of ethics, democracy, and education; it defines the content of each of these and the end at which each must aim." (4) "The slowly made race-made culture as held by any group is the chief educative factor to determine how the members of that group will think and feel and act." (5) "Learning goes on best in the degree that the individual himself sees and feels the significance, to his own felt needs, of what he does." (6) "Change is inherent in human affairs. The future is not yet fixed. Effort counts but the event is precarious," and (7) "The free play of intelligence is our final resource to tell us what to think and do in all individual and social affairs—intelligence playing freely upon experience in any and all its content, including the use of intelligence itself.

Learning may be defined as "any content or phase of living or experience which stays on afterward with one to affect pertinently one's further living. . . . Each one learns what he lives; which means that he learns his responses, only his responses and all his responses, learning each as he accepts it in his own heart to act on and live by." —C.M.P.

Hutchins, Robert M. "Ethics, Politics and Education." *School and Society* 54:257–261; October 4, 1941.

The author makes a plea for cultural education as the only type affording real freedom. Studies in the natural sciences and social sciences are not enough. He says "Neither the free elective system nor the program of the Progressives can give us the education we are seeking." He questions the values of such courses as the Personal Conduct course of New Brunswick (result of a football trip to Miami, Florida), Radio Appreciation in Newark, Straw-sewing in St. Louis, Rug-weaving in Milwaukee, or personality quotients in Vermont. In "taking a dig" at the Progressives, Hutchins quotes Butler of Columbia who describes Progressive education, as "the rabbit theory of education" in which "any infant is encouraged to roam about an enclosed field, nibbling here and there at whatever root or flower or weed may, for the moment, attract his attention or tempt his appetite . . . those who call this type of school work progressive reveal themselves as afloat on a sea of inexperience without chart or compass or even rudder." —C.M.P.

Wiggam, Albert Edward. "Do Brains and Character Go Together?" *School and Society* 54:261–265; October 4, 1941.

In reply to a questionnaire study more than 90 per cent gave an affirmative reply to the following three questions: (1) Do you believe that most geniuses lead loose, immoral lives? (2) Do you believe that a majority of exceptionally brilliant men and women are unstable in temperament, given to drink and likely to carry on unconventional sex relations? and (3) Do you believe that most child prodigies are nervous, maladjusted, hard to manage, likely to become mentally and morally unbalanced adults?

Studies by Terman, by the author and Maller show that brains and character go together to a high degree. —C.M.P.

Hubble, Edwin. "The Rôle of Science in a Liberal Education." *The Wiley Bulletin*, December, 1941.

Liberal education is the process by which we attempt to transmit to the next generation the heritage of culture which our own generation

possesses. The heritage of culture can be analyzed into two ingredients—knowledge and wisdom, or in other words, science and values. The realm of science is the public domain of positive knowledge. The world of values is the private domain of personal convictions. Knowledge is public property. Wisdom is strictly private. The essential characteristic of science is very simple in idea—the attempt to ascertain objective truth without regard to personal desires. A unique feature of science is the fact that it is progressive. The methods of science may be described as the discovery of laws, the explanation of laws by theories, and the testing of theories by new observations. Pure science is not all conceived with the idea of being a benefit to mankind. The most important requirement for university education is the introduction of real mental discipline into the secondary schools. Vocational training should be removed from universities and turned over to an enlightened public school system. —C.M.P.

Conant, James B. "How Can a Democratic Nation Fight a War and Still Stay Free?" *School and Society* 54: 313–315; October 18, 1941.

The author answers the above question by saying "We can do so only if each individual is willing through self-imposed discipline to make sacrifices for the ideals he worships. A democracy preserves itself not by mob hysteria nor by governmental regimentation, but by a voluntary closing of the ranks. —C.M.P.

Bryan, A. H. "The High School in Wartime." *Journal of the National Education Association* 31: 60–61; February, 1942.

This article suggests that the high school may well include in its curriculum some materials that have military or National Defense value. A brief paragraph devoted to each of the subjects, biology, chemistry, physics, and mathematics points out some of the topics which could well be included in these subjects.

—O. E. Underhill

Symposium. "Total Defense; Training for National Defense; America's Outposts." *Building America* 7: 1–64; October, November, and December, 1941.

These illustrated articles discuss various aspects of the American total defense program. Material especially useful for classroom discussion is emphasized. —C.M.P.

Symposium. "The Schools and Defense." *Teachers College Record* 43: 1–23; October, 1941.

This symposium presents community programs for teachers and other educational specialists. Brief articles are as follows: (1) "Citizenship Education for Aliens" by William F. Russell, (2) "Educating for Democracy" by Thomas H. Briggs, (3) "Defining the Issues" by Lyman Bryson, (4) "Pre-Induction Education for Military Service" by Nickolaus L. Englehardt, (5) "Physical Fitness" by Clifford L. Brownell, (6) "Nursing and Defense" by Isabel M. Stewart, (7) "The National Diet" by Grace MacLeod, (8) "The School Cafeteria" by Mary deGramo Bryan, (9) "Vocational Fitness" by Hamden L. Forkner, (10) "Vocational Guidance and Defense Occupations" by Harry D. Kitson, (11) "Consumers and Total Defense" by Harold F. Clark, (12) "How Teachers Can Contribute to National Morale" by Goodwin Watson, (13) "Cultural Relations between North and South America" by I. L. Kandel, and (14) "The Long View" by Merle Curti. —C.M.P.

Symonds, Percival M. "Supervision as Counseling." *Teachers College Record* 43: 49–56; October, 1941.

Supervision is usually thought of as a process which is essentially educational. Most supervisors are immediately concerned with the teacher's methods and skills. Dr. Symonds in this article takes the point of view that the supervisor is primarily concerned with the teachers attitudes and adjustments. The one need teachers have above all others is to avoid feelings of inferiority. This feeling is widespread. Teachers feel inadequate in their work. They feel personally inadequate, that they are not living up to their own high standards, and that they are not appreciated by others. To help teachers gain confidence in themselves is the supervisor's most important task. —C.M.P.

Andrews, Benjamin. "Consumer Education." *Teachers College Record* 43: 199–210; December, 1941.

Consumer education concerns the improvement of living by thoughtful selection and wise use of the resources for consumption. It concerns one-half of the experience-use of resources, planning for use, and satisfactions secured during and subsequent to use. It is the prerogative of no one school subject. Four aims have had most attention in consumer education: (1) buymanship or wise selection in retail markets, (2) training in money management, or personal and family finance, and economics, including budgeting, (3) choice making and the development of a practical philosophy of values to guide choices, and (4) to teach consumer citizenship or the social economics of the problems involved. Consumer education is coming into the schools in three ways: (1) integrated curriculum with consumer education as one of the core subjects, (2) consumer education as a part of special subjects such as home economics science, social studies, etc., and (3) as a separate course. —C.M.P.

SYMPOSIUM. "Practical Experiences in Democracy." *The Clearing House* 16: 3-23; 77-99; 140-142; September, October, and November, 1941.

This is a series of articles as follows: (1) "Block Beautiful" by Lucile Spence, (2) "Community Life Problems" by James A. Sheldon, (3) "Pupil Bus Officers" by Harlow E. Laing, (4) "Hands Off the Student Council" by H. Keith Cady, (5) "Democratic Algebra" by L. C. Wright, (6) "Home Economics" by Martha G. Templeton, (7) "Visual Aids Club" by Don G. Williams, (8) "Dean's Committee" by Calanthe N. Brazelton, (9) "A Twelfth Grade Studies Public Opinion" by Stillman M. Hobbs, (10) "Pupils Share in Control" by Frank Meyer, (11) "Each Freshman Girl Has a Big Sister" by Ethel Rosenberry, (12) "Let Me Do It" by Jen Jenkins, and (13) "Framingham Facts" by Mildred P. Ellis. —C.M.P.

KLAPPER, PAUL. "Education, Builder of Human Relations." *School and Society* 54: 341-343; October 25, 1941.

Education is the social function that is at once most censured and most praised. Every social ill has been laid at the door of the school. Every new social hope becomes an added obligation of the teacher. Human relations are influenced rather than built, shaped and sharpened, rather than created by education. Human relations are outcomes of a complex of controlling forces. They are determined by geographic forces. —C.M.P.

JONES, EDITH SEYMOUR. "The Troubles of the Modern Parent." *School and Society* 54: 376-387; November 1, 1941.

The writer looks askance at the modern school and questions many of its practices. —C.M.P.

SISSON, EDWARD O. "Foreign Language as an Educational Problem." *School and Society* 54: 369-375; November 1, 1941.

The main thesis of this paper is that the place and values of foreign language studies in secondary schools has not as yet been determined. Although the author has studies and taught several languages, he is unable to satisfactorily answer the question of place and values. —C.M.P.

SYMPOSIUM. "High School Methods with Superior Students." *National Education Association Research Bulletin* 19: 156-197. September, 1941.

Major problems discussed include: (1) "Characteristics of Superior Students," (2) "Points of View Concerning the Education of Superior Students," (3) "Current School Provisions: Organization and Administration," (4) "Current School Provisions: Curriculum and Instruction," and (5) "Concluding Statement." Science is one of the specific curriculum areas given brief special treatment in the Bulletin. —C.M.P.

SYMPOSIUM. "The University High School Study of Adolescents." *University High School Journal* 19: 177-219; June, 1941.

This is the fourth article in a series relating to an investigation sponsored by the General Education Board and directed in the interest of guidance service and curriculum development. Major topics in this article are: (1) "Characteristics of high school students," and (2) "Goals of the students in the University High School study of adolescents."

A total of 287 goals were listed for the 105 students. About 66 per cent of the students evidenced two or three goals. Of the 287 goals, 156 were long term goals and 132 were immediate goals. The first large goal involved economic considerations, the second large group, social relationships, and the third, personal satisfactions. —C.M.P.

SYMPOSIUM. "Schools and the 1940 Census." *National Education Association Research Bulletin*" 19: 204-231; November, 1941.

Supplemented by sixteen telefact charts, this Bulletin discusses the following aspects of the census statistics as they relate to schools: (1) "Growth of Population," (2) "General Characteristics of the Population," (3) "Mobility of Population," (4) "Occupations and Employment," (5) "Education," and (6) "The Task Ahead." —C.M.P.

WALTER, RAYMOND. "Statistics of Attendance in American Universities and Colleges, 1941." *School and Society* 54: 539-559; December 13, 1941.

This article presents student attendance statistics from 669 approved universities and colleges in the United States. The 1941 enrollment was 838,715 full-time students or 9.16 per cent less than a year ago. The grand total including part-time and summer session students is 1,269,354 or 8.88 per cent less than last year. The University of California (13,968) ranks first in total full-time students, University of Minnesota second, and Columbia third. New York University ranks first (31,356) in all resident students, Columbia second, and City College of New York third. —C.M.P.

RYANS, DAVID G. "The 1941 Administration of the National Teacher Examinations." *School and Society* October 25, 1941.

This is a report on the National Teacher Examinations. Results of the first two examinations are revealed as encouraging. Examinations are of the objective, multiple-choice type. Areas covered: (1) reasoning ability, (2) understanding and use of the English language, (3) general cultural information, (4)

understanding of points of view and methods of professional education, (5) knowledge of contemporary affairs, and (6) mastery of the subject matter to be taught. —C.M.P.

Booker, Ivar A. "Reading—Every Teacher's Job!" *Journal of the National Education Association* 31:45; February, 1942.

This article emphasizes that "Reading is not a simple skill. It is a highly complex achievement, more nearly comparable to playing a musical instrument." The indifference of high school teachers and high school principals, and in many cases their unawareness of the real problems of the reading difficulties of high school students is pointed out. It is stressed ". . . that average readers and even superior readers should be helped in developing better reading skills often by procedures quite similar to those used with students whose habits are less mature." The responsibility of every teacher in each subject matter field to see that his pupils can read the materials and become acquainted with the special vocabulary of each subject is emphasized. It is possible that science teachers are more guilty of such omission than teachers in other subjects because of the greater number of unfamiliar terms which must be taught in this area.

—O. E. Underhill

Glicksberg, Charles I. "Definitions in Education." *The High School Journal* 25:18–25; January, 1942.

Although written from the general teaching point of view, this excellent article should be read by every high school science teacher. The reviewer believes that science teachers as a whole are at least as guilty as any other subject-matter group, of improper use of definitions in teaching. ". . . the eagerness with which educators, students, and laymen crave definitions must spring from some deeply rooted psychological source. . . . The power that definitions have over us is due largely, one suspects, to our desire to establish a closed and secure universe. . . . The object of this essay is to demonstrate first, that teaching by the method of definitions is not only complex but difficult and often treacherous (defining is a tricky process of abstracting); second, that the teaching of formal definitions in the secondary schools is wasteful, ineffective, and confusing; third, that the memorization of definitions is too often regarded as an expedient substitute for the hard work of thinking and teaching; fourth, that a definition has as much meaning and value as the pupils are able to furnish out of their store of first-hand experiences and antecedent meanings (it is not in itself an aid to learning); finally, that teaching by definition, a device inherited from scholasticism, calls for extensive educational research to determine which methods are appropriate for a given area of subject matter and for pupils of a certain age and intelligence." The reviewer is tempted to quote more, but will leave it to the interested reader to look up the article, and will close by quoting the last sentence of the article: "According to this conception, the definition comes last, not first; it is the culmination, not the beginning of the learning process."

—O. E. Underhill

Book Reviews

GENERAL EDUCATION BOOKS

RISK, THOMAS M. *Principles and Practices of Teaching in Secondary Schools.* New York: American Book Company, 1941. 728 p. $3.00.

This is the newest of the general methods books for secondary school teachers. The author is professor of education and director of teacher training at the University of South Dakota. The book is intended as a text for courses in secondary school methods in teachers colleges or schools of education.

The book contains a wealth of useful and practical suggestions. The descriptions of teaching techniques are well done. Bibliographies are extensive. The literature of the field is well covered.

The whole volume lacks a consistency of approach and a unified philosophy which could serve to weld the various parts together. For example: In chapter two the author presents many samples of detailed daily lesson plans. In chapters thirteen to fifteen he presents with many illustrations unit planning, organization, and teaching. But, in chapter seventeen he returns to emphasis upon detailed daily written lesson plans. Still later in chapter nineteen he is back to unit planning and organization.

The reader's impression is that the author actually believes in daily planning of subject-matter lessons but hesitates to fully commit himself to such an apparently conservative position.

For its wealth of useful descriptive material the book is recommended either for the teacher's library or as a reference for classes in methods and techniques of high school teaching.

—R.K.W.

RUCH, FLOYD L., MACKENZIE, GORDON N., AND MCCLEAN, MARGARET. *People Are Important.* Chicago: Scott, Foresman and Company, 1941. 283 p. $1.32.

People Are Important is essentially a high school guidance book, using principles of applied psychology in dealing with adjustment problems. It provides materials which will aid high school boys and girls in solving their personal and personal-social problems.

Case studies are used extensively to show problems of young people. Each unit is introduced by illustrations and an appropriate discussion. Activities and exercises within the body of each unit serve to focus students' attention on their everyday experiences. An up-to-date bibliography is given at the end of each unit under the heading "In Case You Are Interested."

This book should be examined by everyone connected with high school guidance programs. Several type forms and attractive photographs are used to make the book appeal to students of the secondary school. The authors are to be complimented on the organization and content of this excellent book.

—Roy V. Maneval.

BOND, ELDEN A. *Tenth Grade Abilities and Achievements.* New York: Bureau of Publications, Teachers College, Columbia University, 1940. 68 p. $1.60.

This is a dissertation dealing with the interrelationships of selected abilities and achievements of a limited number of tenth-grade pupils in an Ohio high school.

The investigator began his work through an interest in the reationship of various phases of reading ability to other school abilities and achievements.

To the reader the study seems to be chiefly a series of exercises in correlations and multiple correlations of value primarily as training for the investigator. The analysis of abilities and achievements is relatively crude. Definitions are not exact. One wonders where abilities leave off and achievements begin. Achievements are primarily concerned with wholes of customary tenth-grade subjects.

The findings show interrelationships between the various phases of reading abilities measured and relationships between these and intelligence as measured on the Stanford-Binet Test of Intelligence, Form L. There are positive relationships between these and the tenth-grade achievements measured, but the correlations are not so high for this series, perhaps not especially significant.

The teacher seeking for practical help in improving either achievements or school abilities is left with little in the way of suggestion or improved insight.

—R.K.W.

NATIONAL EDUCATION ASSOCIATION. *Addresses and Proceedings of the Seventy-ninth Annual Meeting,* 1940–41. Washington, D. C.: the Association, 1941. 991 p.

Here are minutes of meetings, reports of committees and abstracts of more than two hundred addresses some of which seem rather inconsequential. A bit more than one percent of the total page space of the volume is devoted to science instruction, while the allied garden edu-

cation runs somewhat less, health instruction a little more. On the whole science instruction does not assume large importance, it would seem, in the eyes of the educational fraternity. Perhaps because the science teacher is usually a scientist rather than an educator. There is a report, p. 598, recommending a National Council of Science Teachers and a journal to be under its control. Perhaps that would help clarify and unify the aims and methods of science teaching as an integral part of a general education.

It is to be hoped that the science teacher who picks up this volume to read the papers on science teaching will not lay it down when that is done. When such men as President Conant of Harvard, President Bowman of Johns Hopkins, the United States Commissioner of Education, the Director of Research of the U. S. Committee on Educational Research, speak, one cannot afford to miss what they have to say. And there are other addresses equally worth while. It is a stirring volume worthy of stirring times.

—E.R.D.

ALEXANDER, CARTER. *How to Locate Educational Information and Data.* New York: Bureau of Publications, 1941. 439 p. $4.00.

According to the author this second edition has been "greatly expanded." The present edition covers several aspects not treated in the first edition and also included many recent improvements not available in 1935. This edition will enable the user to locate educational information and data far faster and more easily, and in more areas than was possible with the 1935 edition. This work makes a great contribution to those making use of the library as a research instrument. It should become the working tool of every library employee, and all persons doing library research may save much valuable time by first reading this fine treatise.

—C.M.P.

ALEXANDER, CARTER. *Alexander Library Experiences.* New York: Bureau of Publications, 1941. 158 p. $1.50.

This is a workbook for use with the author's *How to Locate Educational Information and Data.* There are 34 units of activities and problems that parallel the content of the text. An Instructor's Manual accompanies this workbook.

—C.M.P.

STREBEL, RALPH F. (Chairman). *Current Practices in Institutional Teacher Placement.* Box 934, Athens, Ga.: National Institutional Teacher Placement Association, 1941. 186 p.

Thirty-five members contributed to this symposium. The volume is descriptive of actual practice carried on throughout the country. All members of the National Institutional Teacher Placement Association contributed and the free expression of opinion has led to some controversial points of view, a really desirable feature of the book. All individuals having direct charge of teacher placement should have a personal copy and all teachers interested in placing their studetns to the best advantage will find this volume of much practical use. The volume makes a most valuable and greatly needed contribution to teacher placement practices.

—C.M.P.

SCIENCE TEACHING

WEBER, LYNDA M. *Functional Health Teaching Syllabus.* Boston: Ginn and Company, 1941. 165 p. $1.75.

This is the report by the Organizer and Director of an experiment by The North Central Association in nine cooperating schools. This syllabus was prepared with the hope that it would be a helpful guide to every school desiring more functional health instruction. Part I of the report presents the objectives and procedures; Part II presents a tentative outline of the course; Part III states the outcomes and evaluations; and Part IV includes the appendices.

There are nine units of teaching material as follows: (1) "Adjustment to the Daily Routine," (2) "Importance of Correct Posture and Its Maintenance," (3) "How Life Goes On," (4) "Efficiency and Health Attained through Well-Balanced, Properly Prepared, and Healthful Foods," (5) "Temperature Regulation as a Health Essential," (6) "Warding Off Infections," (7) "Mental Hygiene," (8) "Characteristics of the Next Generation," and (9) "Community Health and Sanitation."

Biology teachers as well as Health teachers will find this report most useful and stimulating. Surely the results of the selective service examinations emphasize the urgent need of the kind of teaching in high school indicated in this study. Thus far, secondary schools have only played at functional health teaching.

—C.M.P.

SYMPOSIUM: *Science Instruction and America's Problems.* Box 16, Austin, Texas: Department of Science Instruction of the N. E. A., 1940. 129 p. $0.50.

This volume includes the papers presented at the Milwaukee meeting in July, 1940. The papers and authors are: (1) "Social Values in Science" by Ben J. Rohan, (2) "How Can These Science Classroom Problems Be Met?," (3) "How Can These Elementary Science Problems Be Met?,"

(4) "How Can These High School Science Problems Be Met?," (5) "Science Contributes to Personal and Community Welfare" by William H. Johnson, (6) "Opinion of Science Teachers" by S. Ralph Powers, (7) "A Rural School Uses Its Community Resources" by Ellen V. Johnson, (8) "Personality Development Through the Medium of Science" by David Russell, (9) "Science Projects" by Irene W. Potter, (10) "Using the Community in Science Unit Organization" by William A. Betts, (11) "Better Approaches to Science" by Hazel Sequin, (12) "Socializing General Science" by Pholip John, son, (13) "Making Physical Science More Useful for High School Students" by Jack Hudspeth, (14) "The Role of Science in Living" by M. J. Phillips, (15) "Science and Showmanship" by Charles E. Kruse, (16) "Contributions of Science to Utilization of Our Resources" by Harold Hand, (17) "How Children Understand Themselves Through Science" by Veva McAtee, (18) "Soil Conservation Taught as a Neighborhood Problem" by Marjorie Campbell, (19) "Elementary Science Enriches the Curriculum" by Gladys Forler, (20) "Dynamic Activities in Science" by Mary Melrose, (21) "Using Simple Equipment in Teaching Junior High School Science" by D. L. Barr, (22) "A Science Program That Functions in the Community" by Elizabeth Cadle, (23) "Soil Conservation in the Junior High School" by Helen M. Strong, (24) "Community Service by Science Instruction" by Margaret F. Burke, and (25) "Recent Improvements in the Teaching of Science" by George Peterson. —C.M.P.

NOYES, ARTHUR A., AND SWIFT, ERNEST H. *A Course of Instruction in the Qualitative Chemical Analysis of Inorganic Substances.* New York: The Macmillan Company, 1942. 418 p. $2.75.

This is the tenth revised and rewritten edition of a qualitative analysis textbook that has had wide usage. Emphasis has been placed on attempting to train the student in careful, systematic analysis similar to that necessary in quantitative analysis. An attempt has also been made to make clear to the student the reason for each operation and result. —C.M.P.

ENGELEDER, CARL J. *A Textbook of Elementary Qualitative Analysis.* New York: John Wiley and Sons, Inc., 1942. 344 p. $2.50.

A great many changes have been made in this third edition. The theory part has been greatly expanded, and in the parts relating to the reactions of cations and anions, the characteristic properties and reactions are discussed. Students using this text will attain both skill in laboratory techniques and in the theories of qualitative analysis. —C.M.P.

MAVOR, JAMES W. *Laboratory Exercises in General Biology.* New York: The Macmillan Company, 1942. 305 p. $2.50.

This laboratory manual has been designed to accompany the author's General Biology. The manual is of the loose-leaf type and with the wide range of topics included provides for a very desirable degree of flexibility. Time-saving devices for both student and instructor have been employed whenever possible —C.M.P.

UNGER, W. BYERS, AND MORITZ, C. E. *A Laboratory Manual for Elementary Zoolgoy.* Boston: Ginn and Company, 1942. 107 p. $1.75.

This manual is based on a one-semester zoology course taught at Dartmouth College. The manual is of the bound-type and a blank page is provided on the right-hand side so that the student may have a convenient space for drawing the structures described on the opposite page.

—C.M.P.

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